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CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH
HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, ACTING DIRECTOR.

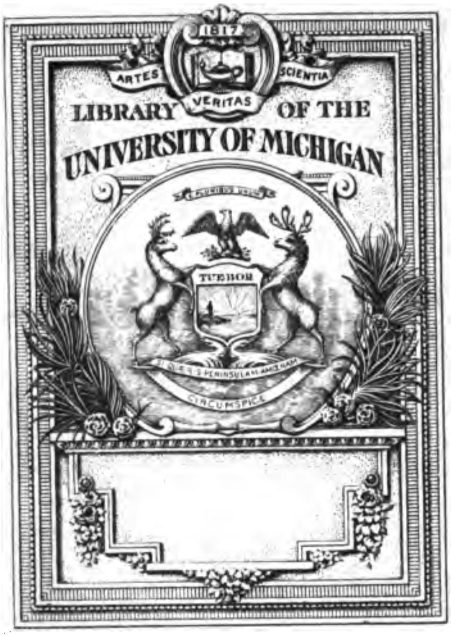
PRELIMINARY REPORT
ON A
PORTION OF THE MAIN COAST
OF
BRITISH COLUMBIA AND ADJACENT ISLANDS
INCLUDED IN
NEW WESTMINSTER AND NANAIMO DISTRICTS

BY

O. E. LEROY

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1908

No. 996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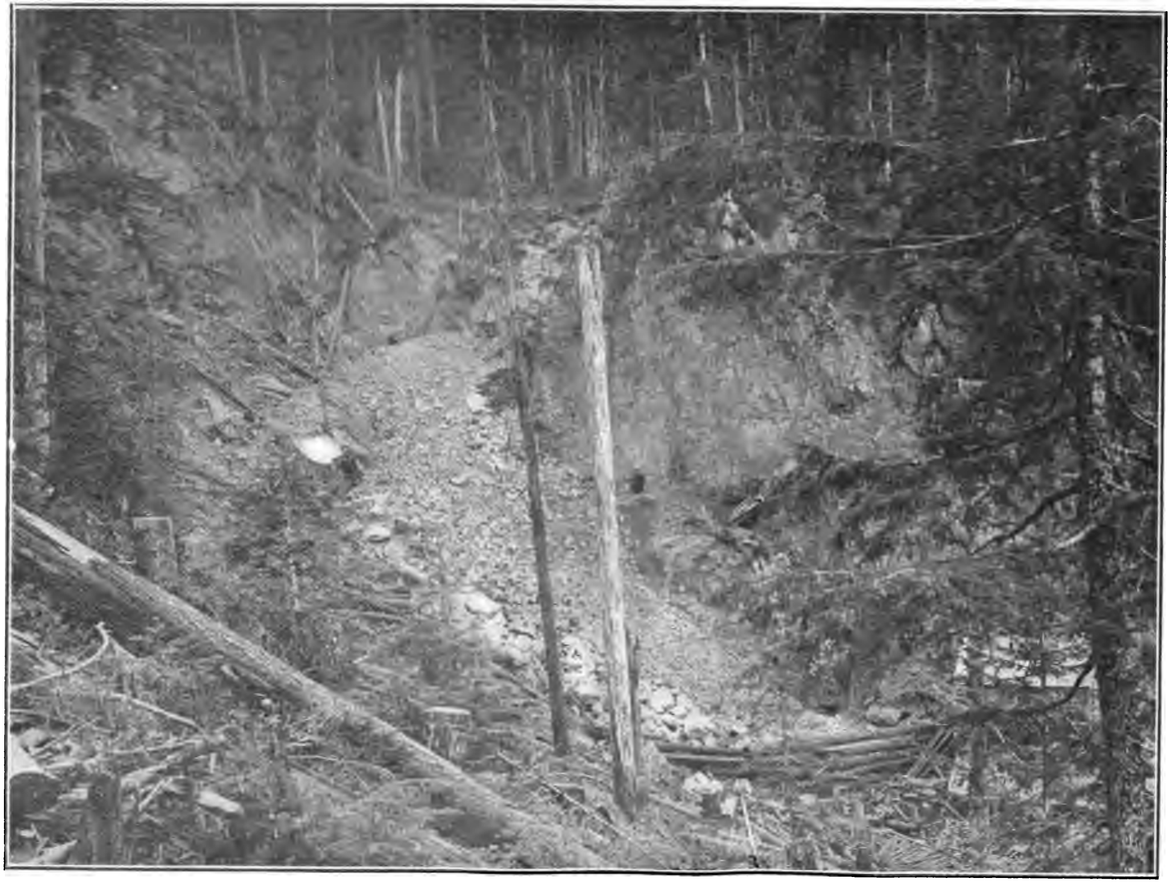

MAMMOTH BLUFF, BRITANNIA MINERAL ZONE, HOWE SOUND.

CANADA. Geological survey

DEPARTMENT OF MINES

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256534

A. P. Low, Esq.,
Deputy Head and Director,
Geological Survey of Canada.

SIR,—I beg to present herewith a report on a geological reconnaissance of that portion of the main coast of British Columbia and adjacent islands included in the mining districts of New Westminster and Nanaimo. In this preliminary examination, which occupied the summer of 1906, especial attention was paid to the formations of economic importance that occur in this region.

To Messrs. W. F. Robertson and H. Carmichael of the Provincial Mining Bureau, Messrs. A. Grant, A. F. Eastman and H. D. Robinson of the Marble Bay mine, and Messrs. M. T. Adams, W. Jacobs, W. H. Lee, H. Youdall, S. F. Raymond and A. S. Going my sincere thanks are due for their courteous assistance in facilitating my work.

I have the honour to remain, Sir,
Your obedient servant,

O. E. LEROY

Ottawa, May 1st, 1907.

NOTE.

In this report distances are given in statute miles, and all bearings are with reference to the true meridian.

INTRODUCTION.

The area described in this report embraces that portion of the coast of British Columbia lying between the International Boundary and the mouth of Powell river on Malaspina strait. It includes Burrard inlet, Howe sound, Jervis inlet and the adjacent islands. With the exception of Texada and Lasqueti islands, the area is wholly in the mining district of New Westminster.

The greater part of this region has not been previously examined geologically. In 1873 and 1875 the late Mr. James Richardson* visited Texada and Lasqueti islands, while the late Dr. Dawson† examined the shores of those islands, and the main coast from Jervis inlet to Powell river, during his reconnaissance trip in 1885.

The present report is of a preliminary character, and the exploration was confined mainly to the shore line, the examination of inland areas being made only where the formations were of sufficient economic importance. Texada island, in its western half, was subjected to a somewhat detailed examination, as it seemingly presented a large area with possibilities for mining under very favourable conditions. The object of this geological reconnaissance was primarily to examine all formations of economic importance, and to secure all possible information with reference to the extent and value of the mineral deposits now known to occur in these formations. At the same time the relations of the various formations were to be studied, in order to elucidate such geological problems as might be presented, this latter work often being an important factor in successfully assisting the exploitation of the narrower and more purely economic horizons.

Owing to the general character of the coast, and the deep indentations or fiords which extend far inland, and present splendid geological exposures along their steep and precipitous walls, it was decided that the easiest and most effective way of travelling would be by water. An auxiliary gasoline launch built for the purpose was therefore used and answered admirably in making a continuous examination of the coast line. This method of work was rendered more effective by the fact that the fiords cross the trend of the coastal belt almost at right angles, and occurring as they do, at comparatively short intervals, the cross sections obtained give a good general idea of the geology of the interfiord belts. At present this is the only method that could be followed, as no work of any value could be undertaken inland without proper topographic maps.

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* Report of Progress, Geol. Sur. of Can. 1873-74 and 1876-77.

† Annual Report, Part B, Geol. Sur. of Can. 1886.

In this preliminary work the Admiralty charts were used and were found to be excellent in giving sufficient topographic information to allow the several formations to be mapped very closely as they occur along the coast.

The geological map which accompanies this report is based mainly on the charts and is on a scale of four miles to the inch. The geological boundaries inland are shown as conjectural but it is believed that they will be found to closely approximate the true contacts.

GEOGRAPHY.

In this region two distinct physiographic types are developed with Burrard inlet as the dividing line. To the south lie the lowlands, which include the Fraser River valley and delta, while to the north lies the Coast range.

From Burrard inlet south the country, with the exception of the prominent ridge between Hastings and Port Moody, is comparatively low and rolling, and is marked by a few parallel ridges of glacial drift with east and west trend. Locally the country is much dissected by narrow and deep ravines. South of the Fraser and extending to the International Boundary the country is plateau-like in character, and represents parts of the old delta of the Fraser, which in the glacial period was formed at the edge of the ice sheet. This delta extends to Point Roberts, and also to Point Grey at the western extremity of English bay. It varies in elevation from 150 to 200 feet above sea level. The post glacial uplift allowed the distributaries of the Fraser to cut deeply into the early delta, and at present a new delta is being formed and is rapidly extending seawards. Richmond, Sea, Annacis and Westham islands, and the plain around Port Guichon, form the greater part of it.

The old channel of the Fraser south of Sand Head lighthouse is now entirely closed to large craft, and the main entrance is one and three-quarter miles northwest of the lighthouse. Dams and training walls have been built to allow for scour, and prevent the present channel from being silted up.

The bottom lands of the flood plain and delta are exceptionally fertile, and offer great inducements to the agriculturist. The higher lands north and south of the river are nearly all drift covered, and consequently the soil is less uniform, and its adaptability for agricultural purposes varies. Much of the land is covered with a luxuriant forest growth, and the lumbering industry is still active. The Coast range, which first reaches the sea along the north shore of Burrard inlet, is the master feature of western British Columbia.

The range has a general trend of north-northwest, and is of a composite character, being broken by fiords and prominent valleys into a series of subordinate ranges which vary in height from 3,000 to 6,000 feet, with individual peaks from 1,000 to 2,000 feet higher. The higher peaks and ridges along the upper reaches and at the heads of the inlets have snow fields and glaciers developed on their slopes. The whole region is extremely rugged, the valleys and the gentler slopes are forested, while the steeper slopes are bare or support a scanty growth of stunted pine. Land slides which have occurred from time to time have left huge scars on many of the more precipitous faces. The summits of the mountains and ridges are usually rounded, sharp peaks and serrated ridges being the exception, below elevations of 6,000 feet.

The fiord system is the most prominent feature of the coast. The fiords represent the old lines of drainage, developed during early Cretaceous and possibly late Jurassic time, when the Coast range suffered from vigorous erosion. The present courses have been determined to some extent by differential erosion along contacts, and by a system of master joints in the granitoid rocks. The later influence of the Cordilleran ice sheet had a considerable effect in modifying these old river valleys. The fiords are bounded by steep slopes and precipitous walls, in many places rising sheer for hundreds of feet from the water's edge. Where the fiord is narrow, particularly near the head where the mountains attain their greatest height, with a shore line marked by an entire absence of harbours and beaches, the general aspect is most impressive.

The narrowing of the fiords at certain points produces very strong tidal currents. The principal ones in this region are the Lions gate at the entrance to Vancouver harbour, and the Skukum Chuck at the entrance to Seechelt inlet. The former is produced by the encroachment of the delta of the Capilano, while in the latter, the naturally narrow channel is blocked by numerous small rocky islands. In both cases the maximum current varies from eight to ten knots.

The fiords head in the swampy land of a low grade delta formed by the streams flowing in the longitudinal U-shaped valleys. The sediments are fine silts, and the front of the delta is very steep to the water, shoaling rapidly from sixty to less than two fathoms. The Squamish, flowing into the head of Howe sound, is a good type of this kind of stream. It carries a large amount of fine sediment, which modifies the colour of the water as far south as Anvil island. A large delta has been built up which is being extended rapidly, and necessitates a long wharf being built to its front for the convenience of steamers.

The lateral valleys are usually V-shaped, and are occupied by swift streams with a succession of falls and rapids. These build at their mouths high grade deltas composed of sand and gravel. The streams are fed by glaciers, or by the less permanent snow fields, and in the latter case their importance varies and is directly dependent on the snow fall of the previous winter. Britannia creek flowing into Howe sound is one of the most important, and has in the last 2·6 miles a fall of 730 feet to the mile, or one foot in seven.

The valleys of Capilano, Lynn and Seymour creeks, flowing into Burrard inlet, are parallel, and analogous to the North Arm of that inlet. Erosion, however, has not been so pronounced nor so effective in these valleys, and their floors are well above sea level instead of being 55 to 100 fathoms below it, as is the case with the North Arm.

There are numerous streams which are of the intermittent, or wet weather type. They have no well defined valleys and their courses are along joint planes, or other accidental channels. The islands of the coast have the same rugged outline as the main land, though the mountains are lower and rarely attain a height of more than 3,000 feet. Texada island, with its mountainous character and bold and rugged shore line, has, when viewed from a distance, the appearance of part of a submerged mountain chain.

GENERAL GEOLOGY.

The rocks of this region are largely of igneous origin and represent a great range from acid to basic in composition, and from volcanic surface flows to deep seated plutonics. The rocks of aqueous origin have a comparatively small distribution.

The almost entire absence of fossils in the latter, and the interrupted character of the exposures, prevent placing these rocks definitely in their proper positions, with the exception of the Cretaceous and the Eocene.

The oldest rocks belong to the Palæozoic era, and have been placed provisionally in the Devono-Carboniferous, though it is possible that some are older. A more extended examination across the Coast range might enable some correlation to be made with the Câche Creek group on the eastern flanks of the range. The rocks are mainly of igneous origin, the sedimentaries forming but a small proportion of the whole, and they occur in isolated areas lying on the granitoid rocks of the Coast Range batholith.

Certain basic eruptives have been placed provisionally in the Triassic (see Fig. 3). In most cases, owing to the subsequent alteration and decomposition, it is impossible to separate them from the associated Palæozoic rocks.

The Coast Range batholith has been referred to the upper Jurassic, though sufficient data has not been collected to accurately determine the age. Subsequent to its intrusion there was a wide spread intrusion of dikes, which cut all the older rocks.

The Cretaceous in this area is represented by a few erosion remnants, occurring on Texada and Lasqueti islands. The Tertiary sediments are of Eocene age, and are not found associated with the Cretaceous. In the vicinity of Vancouver these rocks are cut by dikes of andesite and trachyte.

The sequence of the above rocks is expressed below in tabular form.

Palæozoic.	Devono-Carboniferous.	Texada group. Made up largely of igneous rocks with some limestones and slates.
		Britannia group. Conglomerates, quartzites, slates, sericite schists.
		Marble Bay formation. Limestones.
Mesozoic.	Triassic (?).	Basic eruptives.
	Jurassic.	
	Upper (?)	Coast Range batholith.
	Cretaceous.	Conglomerates, sandstones, shales.
Tertiary.	Eocene.	Puget group. Conglomerates, sandstones, shales with little impure lignite.
	Post-Eocene.	Trachytes and andesites in flows and dikes.
Quaternary.	Pleistocene.	Boulder clays with some modified drift.
	Modern.	Stratified gravels, sands and clays.

PALÆOZOIC.

DEVONO-CARBONIFEROUS.

Rocks of this age, originally wide spread in the coastal belt, are now continuously developed only off the western margin, commencing on Merry island and continuing through Thornmanby and Texada islands. In the Coast range proper they occur as isolated areas lying on the granitoid rocks, and vary in extent from a few feet square, to areas of 100 square miles or more. The smaller exposures occupy the lower slopes of the ridges and of the valley bottoms, while the larger, extending over divides, are found on some of the highest peaks in the district.

From an economic point these Palæozoic rocks are of great importance, as nearly all the mineral deposits of any value are either found in them, or along their contact with the granitoid rocks of the Coast Range batholith.

It has been found convenient to separate these rocks into three divisions, according to their lithological character.

These are in ascending series :

Texada group.
Britannia group.
Marble Bay formation.

The distinguishing names have been taken from localities where the development of the divisions is most typical. The comparative age of the two last is not known, as they do not occur associated with one another, but both are younger than the Texada group which they overlie, the line of junction being either a fault, unconformity or igneous contact.

TEXADA GROUP.

This group consists of a great variety of rocks of igneous origin, forming a great basic complex, along with a few interstratified and now highly altered sediments. The rocks are agglomerates, breccias, tuffs, porphyrites, diabases, lavas, schists, slates, cherts and crystalline limestones. Conditions of vigorous volcanic activity must have alternated with quieter periods, when true sediments interbedded with tufaceous ash rocks were deposited in local and separated basins.

With the exception of the tuffs, slates, cherts and limestones which are usually well bedded or banded, the other rocks are generally massive, though here and there when broadly viewed occasional stratiform structure can be detected. Combined dynamic and thermal action have locally produced sheared and schistose types, and in some cases finely laminated crystalline schists, these latter being found chiefly in contact with later intrusions.

In colour the rocks are prevailingly some shade of green or dark grey, weathering in lighter tones of the same colours. The amount of alteration has been great, and a large proportion of the rocks is made up of the ordinary secondary minerals. In many instances alteration has so far advanced that it is impossible to determine the origin with any degree of accuracy.

The agglomerates are massive without any traces of bedding. They are composed of angular and sub-angular fragments of basic igneous rocks,—now largely altered and silicified, and angular grains of feldspar and quartz in a matrix of chlorite, calcite and epidote. In places the rock becomes more uniform, and passes into a coarse tuff in which there are few large fragments. On exposed surfaces the fragments weather in relief, and the whole rock assumes a dirty brownish grey colour. The agglomerates are well developed on Texada island, forming hills nearly 1,000 feet high. They appear to lie near the base of the Texada group.

The porphyrites are dense textured green rocks, with porphyritic structure, weathering greenish or brownish grey. They are all basic, and have either hornblende or augite as the essential dark constituent. As a rule they are much altered, with a great development of secondary minerals, and in their sheared and schistose facies are represented by chlorite and epidote schists, in which the fractured feldspar is the only distinguishable original constituent.

Under the microscope they are seen to be composed essentially of twinned feldspar, usually labradorite, in well formed phenocrysts and green hornblende or colourless augite. Both the hornblende and augite may be present together, and in some cases the former is secondary. The matrix is made up of laths of feldspar and grains of hornblende and augite. The rocks are never fresh, and the feldspar contains carbonates, epidote and zoisite as decomposition products; the augite alters to chlorite or hornblende, and the hornblende to chlorite. Pyrite, hematite, quartz and especially magnetite are common secondary minerals in addition to the above.

The diabases occur both as flows and dikes. As in the case of the porphyrites they are much decomposed and a great proportion of the rock is secondary. Some types are porphyritic, and in some a pseudo-vesicular structure is shown, which when examined microscopically is seen to consist of sub-angular cavities, with calcite and epidote replacing the original material.

The tuffs are but sparingly represented, and occur over small areas on Anvil, Hutt, Pasley, Thornmanby and Texada islands. They are as a rule well bedded in alternating light and dark grey bands, interstratified at times with cherts, slates and soft schists. They have been much disturbed, and their present attitude varies from 60° to vertical.

Under the microscope they are found to consist of fragments of feldspar and quartz, in a matrix of quartz, turbid carbonates, epidote, zoisite, magnetite and pyrite.

The cherts have their largest exposure at Roger-Curtis point, Bowen island. The rock is dense black, weathering light brownish grey, and occurs well banded in thin beds. The beds are faulted, and their attitude is almost vertical. A few intercalated dikes are associated with them, and these have been sheared into soft schists.

Microscopically the chert is composed of crypto-crystalline quartz, with considerable carbonaceous dust, and small amounts of calcite and pyrite.

The schists, which are the metamorphic equivalents of the porphyrites and tuffs, are thoroughly recrystallized with additional silica. They are finely laminated dark grey and green rocks, weathering in lighter tones of the same colours. The strike usually coincides with the contour of their contact with the granitoid rocks of the Coast range, and the dip is high - 50° and over,—and away from the contact. The principal varieties are biotite, actinolite and augite schists, with quartz. Microscopically the rocks are composed of mosaics of grains in parallel bands. The feldspar and quartz are clear and show slight strain shadows. The former is rarely twinned. The dark constituents are colourless augite, green hornblende, columnar actinolite and brown biotite, with small amounts of epidote, zircon, apatite, pyrite and magnetite.

Crystalline limestones occur at Middle point, on the main coast, in a few small contorted and faulted beds, which are lenticular and pinch out along the strike.

On Hardy island, Jervis inlet, the limestone occurs as a narrow band with a visible width of a little over fifty feet. This band strikes across the island and runs inland on Nelson island for a short distance, where it is cut off by the granite. In part the rock is flat lying, and in part highly contorted. It is a fine-grained, impure crystalline limestone, with a pitted or fluted weathered surface. It holds long narrow areas of siliceous material filled with pyrite, which coincide with the bedding planes and represent subsequent mineralization.

In both the above occurrences the limestone is closely associated with finely banded siliceous schists.

BRITANNIA GROUP.—This group consists of conglomerates, quartzites, slates and quartz mica schists in which the mica is biotite, muscovite or sericite. The slates are the most important, and nearly the whole group is composed of that formation.

The conglomerates and quartzite have limited exposures, and have been found at and near Britannia beach, Howe sound, underlying the slate formation. The conglomerate is a light grey massive rock, with large and small lenticular and rounded fragments of granite in a quartz feldspar matrix. It has a rude strike along vertical shear planes of N. 72° E.

The quartzite is also massive with traces of bedding, showing a strike of N. 35° W. with a dip to the S. W. from 45° to 80.° It is thoroughly recrystallized, and is composed of orthoclase and quartz with small amounts of plagioclase, biotite, chlorite and pyrite.

The slate formation, without these basal rocks, occurs on the east shore of Anvil island and opposite on the mainland; also on the north shore of Gambier island, and on the mainland extending up the valley of Potlatch creek. It is stated that the last band has been followed across country to Deserted bay on Jervis inlet, and has been found to be continuous.

On Jervis inlet, about two miles and a half south of the upper end of Princess Royal reach, the slate formation outcrops along the shore, and with the exception of a few small exposures of granitoid rocks, and a narrow band of the Texada group, is continuous along Queens reach to and beyond its head. The formation is here exposed for a length of twenty miles, with a minimum width of six miles. The highest ridges and peaks along this reach are composed of slates, and a moderate estimate would give the formation a thickness of 6,000 feet at least. The strike is usually along shore, and the bedding planes, now in most part obscure, vary from horizontal to an inclination of 30°. The cleavage is at right angles to the bedding and is well developed. Except at Point Patrick the strikes and dips on the map are those of cleavage. Faulting is common, especially near the margin, but the throws so far as noted were small. On Jervis inlet, opposite Moorsan bluff and at

Saumarez bluff, the slates and associated beds of feldspathic sandstone are cut by a series of porphyrite dikes, which have altered the sedimentaries in part to mica schists, with the plane of schistosity or cleavage parallel to the length of the dikes. The rocks are almost vertical, and the contrast in colour, together with the height of the cliff exposures, makes the occurrence a very prominent feature.

The slate is a dark grey or black carbonaceous rock, usually well laminated with films of pyrite occasionally on the cleavage planes. It passes at times into glossy greenish slate, with wavy lamination. In contact with granite it is altered to hornfels and biotite schist.

Quartz sericite schist, which in part represents an altered slate, occurs as the upper member of the group along the Britannia mineral zone which runs inland from Britannia beach.

THE MARBLE BAY FORMATION.—This formation consists of limestone, and is represented on Texada island, in its northwest half, by a broad band which has a length of seven miles, with a maximum width of two miles (see figure 3). Small outliers occur at different points on the island which indicate a much more extensive area in former time. From the scanty fossil evidence the formation would be placed either in the Carboniferous or Devonian. The rock varies, dependent upon metamorphic influences, and passes from a quite unaltered limestone to a pure white marble. The unaltered rock found at Limekiln bay is a dark grey very pure compact limestone occurring in beds from one to three and a half feet in thickness. The beds are but slightly disturbed and dip seawards at 15°.

In the vicinity of Blubber bay and elsewhere the rock assumes a lighter tone of grey and is crystalline. At the contact with dikes the rock becomes a white fine-grained marble. The metamorphic zone is very irregular, and in cross section varies from a few inches to several feet, with the white marble passing insensibly into a less altered form. On the north shore of Sturt bay a similar marble has been formed by a small intrusion of granite; the marbleized area is larger and the rock is more uniform. The formation is much faulted, thus preventing any computation being made as to the present thickness of the limestone.

TRIASSIC ?

The above groups and formations are associated with igneous rocks of a later period, which occur as dikes and intercalated sills and masses. The intrusions in the rocks of the Texada group can only be dis

Looking up Howe Sound

tinguished in a few places, owing to the amount of alteration and the similarity in composition. In the slates and limestones the relations are plainly seen showing these eruptions as broad sills that have intruded along the contact between two formations and along the bedding planes. The eruptives are both volcanic and plutonic, and incline towards the basic end of the series, being principally hornblende and augite porphyrites, diorite, gabbro, with some quartz and syenite porphyries. They have been provisionally placed in the Triassic and are at all events older than the Coast Range batholith.

At certain localities considerable areas of these rocks may be associated with the Texada group, but without very detailed and laborious work, it is impossible to separate them.

UPPER JURASSIC (?)

The Coast Range batholith.—The Coast Range batholith extends in a north-northwesterly direction from the Fraser valley to the White River basin in the Yukon territory. It is the master geological feature of the coastal belt of British Columbia, being nearly 1,000 miles long, and from 30 to 100 miles broad. The present description only applies to that part of the batholith accessible from the coast, lying between Burrard inlet and Powell river.

The batholith intrusion has been referred to the Upper Jurassic provisionally. It is younger than the Triassic, but older than the Cretaceous coal measures.

The term granite has been used as a general field name which strictly can only be applied to a small portion of this enormous intrusion. The less siliceous types of the plutonic rocks are well represented, and the whole batholith varies in composition from an acid granite to basic gabbro. The more basic types are usually at or near the contact with the overlying remnants of the old roof covering of Palæozoic rocks.

The rock as a rule has a granitoid texture, and varies from medium to coarse grained. At or near a contact a narrow marginal zone may be porphyritic with quartz phenocrysts in the acid, and feldspar or hornblende in the basic types. Along many of the contacts the granitoid rocks are more or less distinctly foliated, and the strike of the foliation coincides with the contour of the contact line.

The contact between the intrusive batholith and the overlying Palæozoic rocks illustrates at many points the powerful action of the magma in preparing chambers for itself, by the rifting and stoping of the roof rocks, and the flotation and absorption of the detached blocks.

These fragments, depending on the fluidity of the magma and its power of absorption, assume different forms. When the rifting was done during the viscous stage of the magma the included blocks were carried but a short distance, hence are close to the contact and have preserved their angular forms. Occasionally the schist and granite may assume a banded structure, where the former has been rifted off in a series of huge slabs that alternate with a variable thickness of granite.

In other occurrences the invaded rock, owing to its original structure, has been broken into smaller fragments. These passing into the magma have been softened and partially fused and the inclusions, due to a slow movement in the magma, have been drawn out into long narrow lenticular, contorted, and elongated dumb-bell forms, which coincide in direction with the foliation of the granite.

In other cases a more fluid magma has quickly absorbed the fragments, which assume rounded forms becoming smaller as the distance from the contact increases, until they finally disappear. In the transitional stages the inclusions resemble basic segregations.

Occasionally, as on the west end of Worlcombe island, the granite has intruded the schist in a series of reticulating dikes with little flotation or absorption of the fragments. The composite rock forms a granite-schist breccia. (No. 1, Pl. III.)

There is a complete absence of contact metamorphic aureoles in the slates, where they have been intruded by the granite. They simply alter to hornfels at the contact, while the fragments included in the granite become quartz biotite schists.

The aplite dikes, with some pegmatites, are very widespread, cutting all varieties of the granitoid rocks and often forming an irregular network system in the schists. In the granites proper, the contact with the aplite varies from distinct to indefinite, the latter passing into the former by insensible gradations. In the more basic rocks the contact is always sharp and definite.

The aplites are light grey or pink in colour, and very fine grained. Microscopically they consist of irregular individuals of orthoclase, albite and quartz with small amounts of accessory microcline. The quartz always shows intense strain shadows. The dark constitutents are practically absent, only a few shreds of partially chloritized hornblende and biotite being noted.

The more acid types of the plutonic rocks composing the batholith are prevailingly white or light grey in colour, passing to dark grey and dark greenish grey in the more basic. They weather in lighter tones and are occasionally rusty from the decomposition of pyrite. The following principal types have been examined :

Biotite and hornblende granites.
Granite porphyry.
Quartz syenite.
Grano-diorite.
Quartz diorite.
Quartz augite diorite.
Quartz hypersthene gabbro.
Gabbro.

There is no hard and fast line separating the different varieties, and over comparatively small areas regular transitions may be found ranging from the acid to basic.

The following tabulated list shows the mineralogical composition of the batholith as a whole :—

Essential.	Accessory.	Secondary.
Orthoclase	Plagioclase	Epidote
Plagioclase albite to anorthite	Muscovite	Zoisite
	Quartz	Calcite
Quartz	Brown hornblende	Leucoxene
Hornblende	Hypersthene	Chlorite
Biotite	Zircon	Hornblende
Augite	Apatite	Kaolin
	Sphene	Pyrite
	Magnetite	Hematite
	Titaniferous magnetite	Magnetite
		Bastite

The usual order of crystallization prevails throughout with a few trifling exceptions.

The feldspars range in colour from white to dark green, and in composition from orthoclase to anorthite. They are rarely fresh and are more or less altered to kaolin, epidote, zoisite and turbid calcite. The stout tabular and slender lath forms are predominant, with smooth crenulated or jagged terminations. Interstitial to the better formed individuals are irregular grains with interlocking borders. The albite twinning in the plagioclase is invariable, with additional pericline or carlsbad. Zonal structure is very common, the zoned individuals having a basic inner and less basic outer zone. In many there is a whole series of zones basic alternating with less basic feldspar.

The ferro-magnesian constitutents are rarely seen with good form, and usually occur in aggregates of individuals with a partial development of one or more crystal faces. Hornblende is occasionally allotriomorphic to feldspar, and biotite to quartz.

The hornblende is the common green variety, pleochroic in deep green, yellowish green and pale yellow tones. It is sometimes intergrown with biotite and augite. A few individuals are twinned on the 100 plane, with one or two thin lamallae between the two larger parts. The common alteration product is chlorite.

Biotite is next in abundance. It is pleochroic in deep brown and pale yellow tones, and alters by bleaching to muscovite, and to chlorite with a separation of magnetite.

The augite is pale yellow or colourless, and is occasionally twinned in the same manner as the hornblende. It alters to compact and fibrous hornblende, and to chlorite.

Hypersthene pleochroic in pale green and red tones is rare and was only noted in two slides. It is surrounded by a reaction rim of compact hornblende, and is in part altered to bastite.

Quartz, with one exception, is present in all the rocks, and generally as an essential constituent. It always shows strain shadows more or less intense, accompanied in many cases by a development of fracture planes. In the granite porphyries it occurs in good forms, otherwise it is quite allotriomorphic. The accessory minerals are in trifling amount, and neither they nor the secondary minerals present any new point of interest.

A few of the principal types have been selected for special description to illustrate the range from acid to basic.

BIOTITE GRANITE, GRANITE ISLAND.—The most typical granite occurs on Granite and Nelson islands, at the entrance of Jervis inlet.

On the former island the rock is a medium grained light grey granite, composed of light grey feldspar, grey vitreous quartz and black glistening biotite. Under the microscope the feldspar is seen to be mainly orthoclase in large irregular individuals with interlocking borders. A small amount of albite is present in good tabular forms, and is idiomorphic towards the orthoclase. Brown biotite, in considerable amount, occurs in lines of poorly formed individuals. The quartz is interstitial, and has both smooth and interlocking borders towards the feldspar. Magnetite, zircon and apatite are present in trifling amounts as accessories.

The grano-diorites contain oligoclase and oligoclase-andesine with considerable orthoclase feldspar, the former being usually zoned. The dark constituents are hornblende, with surbordinate biotite and augite. Quartz is always present and generally in large amount.

QUARTZ DIORITE, TRAIL ISLANDS.—Microscopically the rock is of medium grain, and is made up chiefly of black hornblende and greenish grey feldspar. Under the microscope the plagioclase feldspar is seen to occur in stout well formed tabular individuals, twinned according to the albite law with additional carlsbad. Irregular grains occupy the interstitial spaces between the well formed. The feldspar is mainly acid labradorite with some andesine. Green hornblende, colourless augite and brown biotite are present in aggregates of poorly formed individuals. The two former are occasionally intergrown. Quartz, magnetite, apatite, zircon and chlorite complete the mineral content.

QUARTZ HYPERSTHENE GABBRO, NARROW ARM, SEECHELT INLET.—This rock occurs in contact with basic schists of the Texada group. To the north and away from the contact it passes by gradual transitions into a granite. The rock is greenish grey in colour, and rather coarse in grain. Microscopically it is composed of plagioclase feldspar ranging from oligoclase to medium labradorite and augite with hypersthene, hornblende, biotite, quartz, magnetite and apatite.

The plagioclase is present in stout tabular and slender lath-shaped individuals with irregular grains interstitial. It is twinned according to the albite law, with additional pericline and occasional carlsbad. Zonal structure is common, showing alternate zones of labradorite and oligoclase. A schiller structure is developed in a few individuals, consisting of numerous minute black opaque rods in parallel arrangement. The augite is colourless, and in part is intergrown with, and surrounded by hornblende. In a few individuals the schiller structure is developed. The hypersthene occurs in rather large individuals surrounded by a reaction rim of compact green hornblende. It is pleochroic in pale green and faint red tones. Only in a few instances do the dark constituents show any approach to good form. They occur in aggregates of individuals, and the hornblende is at times quite allotriomorphic to the feldspar. Magnetite, probably titaniferous, is present as grains and narrow bands along the cleavage planes of the hypersthene and biotite. The quartz is in quite small amount.

Gabbro, White Cliff point, Howe sound.—This rock type is the most basic found, and the only one characterized by an entire absence of quartz. It is a medium grained, dark grey gabbro and has in the field a comparatively small exposure. Microscopically the rock consists of labradorite and anorthite feldspar, augite, with small amounts of brown and green hornblende, biotite, apatite, chlorite, pyrite and magnetite. The feldspar occurs in tabular form and irregular grains. It is twinned according to the albite law and a few individuals have carlsbad twinning in addition. The augite is both idiomorphic and allotriomorphic, and has altered largely to a fibrous hornblende.

The foliated types vary in composition from granite to quartz diorite, and are found at or near the contact of the batholith with the overlying Palæozoic rocks. There are two origins for the foliation; the first is caused by an alignment of the minerals during the cooling stages of the magma, while the second is the result of dynamic action subsequent to final or partial solidification.

In the first case, while the quartz and feldspar show the effect of a certain amount of strain, there is an absence of fracturing and granulation. In the second case, fracturing and granulation of the light constituents are prominent features and in extreme types the original grains have disappeared with complete granulation.

At a period subsequent to the intrusion of the Coast Range batholith, and prior to the Cretaceous coal measures, the older rocks were invaded by a great series of dikes consisting of diabase, augite porphyrite, quartz hornblende porphyrite and syenite porphyry. With the exception of the syenite porphyry, which is older than the more basic, these dikes are closely related and may represent variations of the same magma.

They vary in width from sixty feet to a fraction of an inch, and are very irregular when traced along their strike. Many hold inclusions of granite which they have rifted off their walls. Diabase predominates over the other types, and dikes of that rock are particularly numerous at the entrance to Salmon and Narrow arms, Seechelt inlet. Subsequent movements have caused some faulting, but the throws are small and generally do not exceed the width of the dike.

CRETACEOUS.

The period succeeding the intrusion of the Coast Range batholith was one of extensive and vigorous erosion. The present drainage system of the coastal belt was initiated, and in its youth was an active agent in transporting rock debris from the mainland across to the sea.

The Cretaceous sediments came from this source, and were laid down along the old margin of the Coast range.

In the district under review rocks of this age occur now only as small erosion remnants on Texada and Lasqueti islands. They are littoral deposits and consist of conglomerates, feldspathic sandstone and shales. They have been but slightly disturbed, and the seaward dip never exceeds 15°. At Gillies bay fossil plants* occur in the sandstones and a small exposure on the south side of Texada island about five miles from Point Upwood contains fossil brachiopods and molluscs.†

In these different exposures the beds are basal and of no great thickness. It is quite improbable that coal seams of any value will be found in them.

TERTIARY.—EOCENE.

Puget group.—The Puget group is developed in two separate regions, one occupying the area between Burrard inlet and the International Boundary, while the other occurs at and inland from Wolffsohn bay on Malaspina strait.

In the former area the rocks are exposed in a series of interrupted bluffs along the south shore of Burrard inlet, from English bay to a point a little east of Barnet. From Hastings to Barnet they form a long ridge known as "North mountain" which, south of Barnet, rises to a height of 1,335 feet. This ridge slopes toward the Fraser river, and it is only on its northern face that continuous outcrops are found.

Southwards to the Boundary no more exposures are seen, as the whole country is covered by glacial drift and alluvium, but the group has an extensive development in the State of Washington.

The group consists of conglomerates, with well stratified sandstones and shales. The beds are but slightly disturbed, with strikes varying from northeast to east and west, and dipping southeast, and south at low angles. The conglomerates consist of well rounded pebbles of schist, granite, quartzite, etc., in a sandy ferruginous matrix. The sandstones are argillaceous, and disintegrate rapidly on exposure. In places they hold small lenticular areas of dark brown lignite. A coarse thick bedded feldspathic sandstone is interbedded with the finer sandstones. It weathers differentially leaving large projecting knobs in the face of the bluffs. The shales are dark grey or black and usually carbonaceous. Some of these beds hold numerous plant remains. The whole group indicates estuarine conditions of deposition, and the area underlain by these rocks in this southwest portion of British Columbia represents but the northern rim of an extensive basin. It has been estimated by Mr. A. Bowman that the group has a thickness of 3,000 feet in the vicinity of Vancouver, while in the State of Washington it attains a thickness of 10,000 feet.

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* Report of Progress, Geol. Sur. of Can. 1876-77, p. 169.

† Mesozoic Fossils, vol. 1, Part V. Geol. Sur. of Can. 1903.

Several collections of the plant remains were made, and were submitted to the late Sir William Dawson for examination, with the result that the group has been placed in the Eocene.*

In Washington the group contains several seams of lignite which are of commercial importance. No coal has been found on the Canadian side, and if any beds exist they are much below the horizon of the exposed beds. The superiority of the coal on Vancouver island will prevent any active prospecting in this group for a coal that would in any case be a very inferior one.

On Wolffsohn bay and Sandstone river there is a series of sandstones which are probably of this age, and have been placed there provisionally. It is supposed there is an extensive basin inland, but the dense forest and heavy growth of underbrush prevent a close examination being made at present. On lot 1803, along the bank of a small creek, the soft sandstones contain thin streaks of impure lignite, but no bed of any value has been exposed.

POST-EOCENE ERUPTIVES.

Effusive eruptives occur in the vicinity of Vancouver as dikes and masses cutting the Eocene rocks. Closely related rocks are found north of Watts point, Howe sound, and are referred to the same age. The rocks vary from dense holocrystalline augite andesites to quartz trachytes with vesicular structure.

The upper ridge of Fairview heights is composed of a dark grey fine-grained augite andesite, which on exposed surfaces weathers readily to a brownish sand. Microscopically the rock consists of phenocrysts of plagioclase feldspar and augite in a matrix of the two. Magnetite is present in large amount as inclusions in the augite.

In Stanley park a dike extends from Siwash rock to Prospect point, and is exposed at several places on the road between these two points. Where it is exposed in the bluff at Prospect point it has a width of fifty feet, and is over 200 feet high. The feldspathic sandstones are slightly altered along the contact, and occasional fragments are included in the dike. The rock is a greenish grey non-porphyritic quartz trachyte with irregular vesicular cavities partially filled with quartz crystals showing pyramidal terminations. In the lower portions of the dike the vesicular structure disappears, and the rock becomes more compact.

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*Trans. of the Royal Society of Canada, second series, 1895–96, vol. i, sect. iv, p. 137.

South of Siwash rock there is a small dike of decomposed andesite which is only exposed at low water.

North of Watts point an eruption of andesite has flowed over the old eroded surface of the granite. It occurs along the shore in bluffs 300 to 400 feet high and rising inland to about 1,000 feet above the sea. The exposure is one mile long and half a mile wide. The surface of the flow is a black vesicular andesite with pitchy lustre and basaltic jointing. This forms the selvage of the grey vesicular rock of the interior part of the flow, into which it passes. Both types microscopically are composed of stout and slender phenocrysts of augite, and a few tabular individuals of medium labradorite, in a matrix of slender laths and acicular forms of plagioclase and augite, and grey or brown isotropic glass. There is considerable magnetite in minute grains. The flow structure is present throughout, but is much better developed in the selvage border than in the interior of the mass.

QUATERNARY.

GLACIATION AND SUPERFICIAL DEPOSITS.—In the region examined the glacial phenomena were purely local, and not of such a character as to bring forward any new information. Most of the data were collected from low levels, as little opportunity was afforded of examining the higher slopes and summits of the ranges. In the glacial period the Strait of Georgia was occupied by the southern extension of the Cordilleran ice sheet, which flowed through the fiords from Bute inlet south, and formed the Strait of Georgia glacier. According to Dr. Dawson this glacier had a thickness of 3,000 feet in the north and about 700 feet at Victoria.* The slate hills in the vicinity of Deserted bay on Jervis inlet are over 3,000 feet high, and are glaciated to their summits. Midway in Princess Royal reach, a peak on the northwest side of the inlet, 4,647 feet high, shows a glaciated summit. This would allow for the Jervis Inlet tributary a thickness of at least 5,000 feet. Where the fiord sides are steep or perpendicular the lateral pressure of the glacier has been very intense, as evidenced by the polished and scored walls and the deep undercut grooves. The striae, showing the general direction of movement, are, as a rule, parallel to the trend of the fiords and the coast line. Local deflections were noted where lateral branches maintained their strength, after the recession of the main ice stream.

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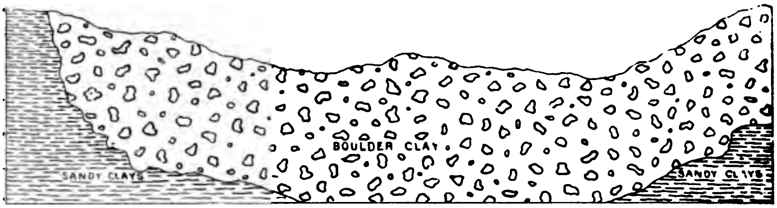
* Trans. of the Royal Society of Canada, vol. viii., sect. iv., p. 34, 1890.

Glacial deposits of any great importance are not found in this part of the coastal belt. Boulder clays, which are rather pure and compact, occur along the northeast shore of Howe sound near its head, on the east shore of Anvil island, and at the heads of the bays along the south shore of Gambier island. A clay belt extends from Gibsons landing along the main coast and terminates near Seechelt. Between Burrard inlet and the Fraser river there is a considerable thickness of sandy boulder clay, in which occur many small areas of modified drift consisting of sands and gravels. These are stratified, with much false bedding, and were formed by sub-glacial streams, and also by those issuing from the front of the glacier at a period of recession. These deposits are invariably covered with one to four feet of boulder drift, which marks a later deposition of the glacier. A certain amount of till occurs south of the Fraser, associated with the alluvial deposits of the old delta of that river.

In the Capilano valley, one and a half miles above the suspension bridge over the gorge, there is a series of well stratified clays, sands and a few lenticular areas of gravel. The evenly bedded character of the deposits shows that the sediments were laid down in quiet water. The highest beds noted were 380 feet (bar.) above sea level. Again, on Lynn creek, about five miles north of North Vancouver, there is a deposit of very pure bluish-grey clays with even horizontal bedding. These are about 885 feet (bar.) above sea level. In both cases the beds are devoid of shells of any kind, and it appears probable that these sediments were deposited in glacial lakes, behind the front of the glacier which dammed the valleys lower down. With the disappearance of the glacial lakes and a renewed activity on the part of the glacier, these beds were eroded in part. In the Capilano valley this erosion produced small valleys in these deposits which are cut with knife-like sharpness and are now filled with boulder clay. Figure 1 is a sketch to scale of one of these small valleys. The work was done by the lateral tributaries of the Capilano glacier.



CAPILANO VALLEY
Stratified deposits eroded by lateral glaciers
Horizontal and Vertical Scales
10 5 0 10 20 feet

FIGURE 1.

At the close of the ice age the land was relatively much lower than at present. The position of the former sea level is marked by beaches which have been preserved in a few localities. On both sides of Texada island, in the northwest half, beaches are found from 300 to 350 feet above sea level. At Powell river on the main coast sands and gravel occur 350 feet above the sea. From these examples it is assumed that the post-glacial depression in this region was at least 350 feet. Seechelt inlet formerly opened in the Strait of Georgia at Seechelt. In late post-glacial time, when the land was but a little lower than it is at present, a sand and gravel bar was built up by long shore currents across the entrance. This bar is now twenty to thirty feet above sea level and 1,100 yards broad.

Between Southeast bay and Welcome point on the mainland, and on the Thornmanby islands, there is a considerable thickness—145 feet on west Thornmanby—of well stratified sands and gravels, with some very fine and pure clays, overlain by false bedded sands and gravels. The basal beds contain large boulders of granite left by the ice sheet. Some of the beds contain large numbers of marine shells, the most common being specimens of *Cardium Nuttali* and *Tapes staminea.*

ECONOMIC GEOLOGY.

The principal areas of economic importance are those occupied by the Palæozoic rocks. The mineral deposits occur in them or along their contacts. In prospecting, therefore, it is important that these rocks should receive the greater amount of attention.

The difficulties which the prospector has to contend with are many in this coastal belt. The whole country is extremely rugged and difficult of access, while rock slides, the luxuriant forest growth and the dense underbrush below the 4,000 foot level, afford effective concealment of contacts and mineral outrops, entailing careful and laborious work.

In most cases the discovered mineral deposits of value are so situated that economic methods in mining and transportation are feasible. Surface or aerial tram lines may connect the mines with tide water, and from there cheap transportation is afforded to the different smelters. The principal metallic ores in this region are those of copper and iron.

The former has been mined for over a decade on Texada island, and the production throughout has been characterized by a high percentage of copper, with good values in gold and silver. On the Britannia mineral zone, Howe sound, the Britannia Copper syndicate have an extensive plant for handling and treating their enormous deposits of low grade ore. This zone is being further exploited, and it is expected that other properties will become shipping mines in the near future. Preparations are being made to mine the low grade ores at Britannia West, and the high grade bornite deposits of Mount Donaldson have received some attention during the past season.

The magnetite deposits of Texada island have been known since the early sixties. Development work up to the present, however, has been of a desultory nature, and comparatively little ore has been shipped. Several deposits of magnetite occur on Vancouver island,* and elsewhere along the coast, but so far hematite and limonite have not been discovered in commercial quantities.

With the growing demand for iron and steel products of all kinds there is an opportunity on the coast of British Columbia for blast furnaces and a steel plant. The coal mines of Nanaimo and Comox should be able to supply coke with a sufficiently low ash content, and the large areas of pure limestone on Texada island and elsewhere could furnish flux. Transportation would be cheap as all the necessary material is at or near the sea coast.

It is to be hoped that capital will be found to make a serious attempt to examine these deposits of iron, with the view of determining their value and extent.

Besides the local there is the general demand for iron and steel commodities along the whole western coast of the Americas, and also the

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* Iron Ores of the Coast, by W. F. Robertson. Annual Report of the Minister of Mines, British Columbia, 1902. pp. 225-229.

Oriental market, where the British Columbia product ought to successfully compete with that of Europe. Japan at present is not able to supply the demand, and with the industrial growth of China a permanent market ought to be assured.

In the following descriptions the mineral areas have been grouped with reference to the inlets and islands.

BURRARD INLET, LYNN CREEK CAMP.

The Lynn Creek camp is about eight miles north of North Vancouver, and twelve miles by trail. It comprises an area of about five square miles, and some thirty-five claims have been staked up to the present. The whole country is extremely rugged, and the narrow valleys are bounded by steep and almost precipitous walls. The hills rise abruptly from the main and tributary valleys of Lynn creek to heights of 3,000 and 4,000 feet.

The country rocks are massive and banded siliceous, epidote and chlorite schists, surrounded by granites and syenites of the Coast Range batholith.

The ores consist of zinc blende, chalcopyrite, pyrite, pyrrhotite, molybdenite and magnetite, which occur as irregular bodies along shear and fracture zones in the schists. The preliminary work on the claims has been mainly of assessment nature, consisting of stripping, small open cuts and tunnels, but in no case has sufficient been done on any one deposit to prove its value.

On the Banker claim, 2,750 feet (bar.) above sea level, the ore consists of a mixture of pyrite and zinc blende and occurs in a brecciated zone about three feet wide. Similar ore occurs in the schists at other points on the same claim. An assay of the ore gave negative results for gold and silver.

On the Mountain Lion and Lynn claims, three tunnels have been driven in on the slope of the hill. The highest is 1,600 feet (bar.) above sea level and is 100 feet long, cutting through a mineralized zone. The ores are coarse pyrite, chalcopyrite and molybdenite in a quartz-epidote-calcite gangue. It was stated that some of the ore carried as much as 3 per cent copper. It was supposed that these prospect tunnels had cross-cut the mineralized zones, but no drifting was done to prove if that was the case.

The Kemptville claims are situated up the west fork of Lynn creek, and are about 2,400 feet (bar.) above sea level. The country rocks are banded grey, white and yellow siliceous schists and are almost vertical in attitude. Two veins of almost pure zinc blende two and three feet wide respectively have been discovered, but the amount of development work has not been sufficient to prove their value. Blende associated with galena occurs on the Evening Star claim to the north of the Kemptville. The following assays of these ores have been made by Mr. G. C. Robbins :

——	I.	II.	III.	IV.*
Lead	....	....	3·00	
Zinc	42·80	34·20	30·60	44·00
Iron	5·70	4·30	2·60	6·40
Gold	0·30 oz.	....	0·02 oz.	
Silver	0·41 ,,	....	3·00	1·50 oz.

I. and IV. Kemptville.
II. Kemptville No. 2.
III. Evening Star.

On Angel claim No. 3, small bodies of yellow copper have been opened up, and this ore is known to occur with pyrite on adjacent claims. With additional work some of the ore bodies may prove to be of sufficient size to make them commercially important. In any case, however, owing to the cost of mining and transportation, it will be necessary to amalgamate the different interests in order to ensure successful results.

HOWE SOUND, BRITANNIA MINERAL ZONE.—The Britannia mineral zone is situated on the east side of the sound and twenty-three miles from the entrance. The associated rocks belong to the Britannia group, and consist in ascending series of conglomerates, quartzites, carbonaceous slates and quartz sericite schists, with intercalated sills and masses of hornblende porphyrites and quartz-syenite porphyries. They have a width along shore of one and a half miles, and extend inland for more than eight miles. The mineralized zone lies almost wholly in the quartz sericite schists, and extends from the Eureka claim to and possibly beyond the Charmer claim, a distance of about four miles. The trend of the zone varies from N. 16° W. in the western part to N. 40° W. in its eastern extension, an abrupt change in strike occurring on the Jane claim, due to a fault. The dip varies from 45° to 85° to the south and southwest. In the central portion, between the Clifton and Last Chance claims, the width of the zone varies from 300 to 600 feet in width. The north boundary or foot-wall consists of the carbonaceous slates, but the south contact is not well defined and is, over parts of the area, a syenite porphyry. All the members of this group have been greatly disturbed and metamorphosed in part, by the intrusion of the Coast Range batholith. The mineralization took place subsequent to the general faulting, and the ore bodies so far have been found free from faults and dikes.

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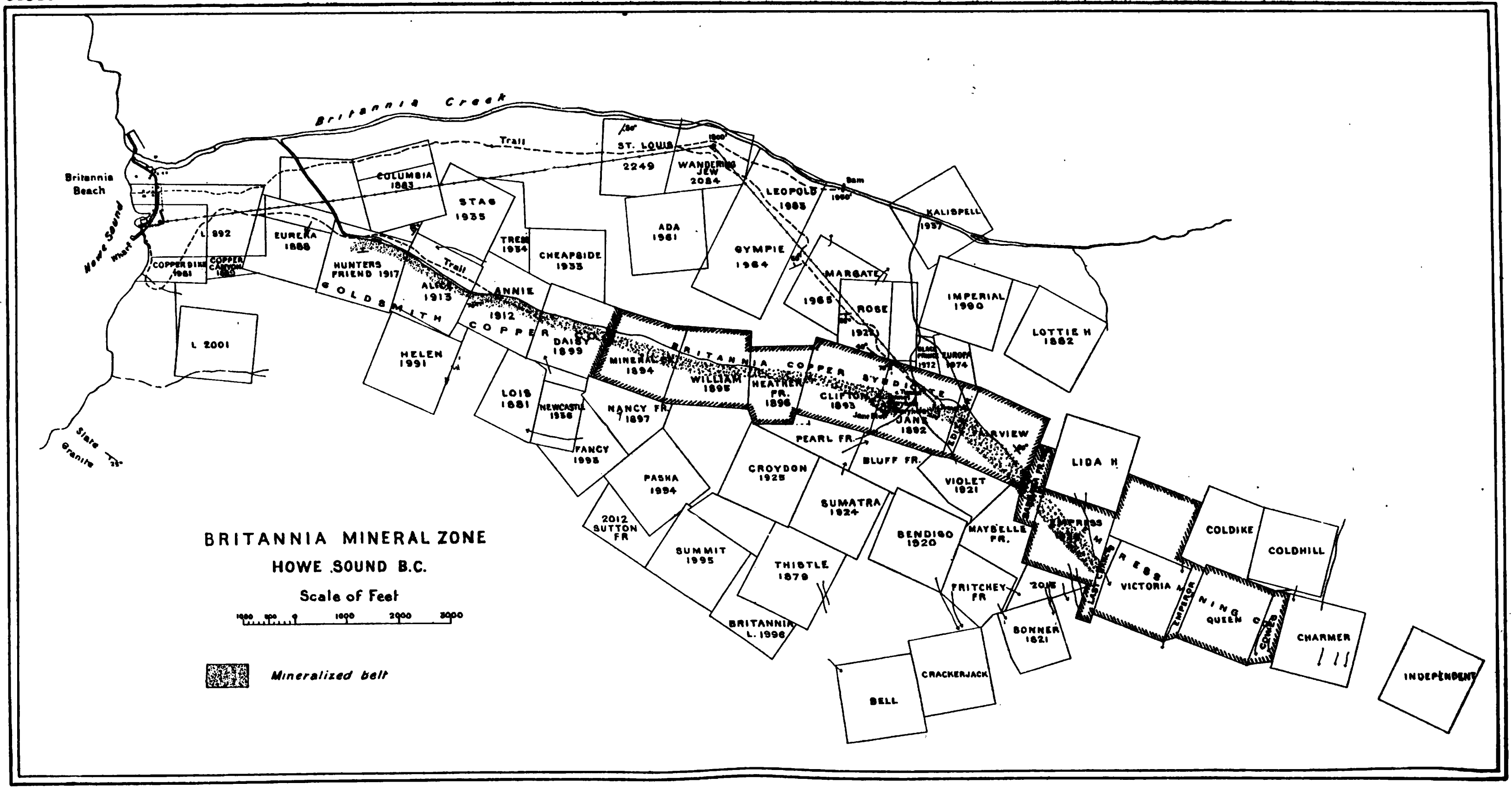
*Report of the Commission appointed to investigate the Zinc Resources of British Columbia. Mines Branch, Dept. of the Interior, 1906.

In the accompanying sketch of the zone (Fig. 2), only part is shown, as it was not possible to ascertain the width throughout the whole length.

The quartz sericite schists are grey and greenish grey in colour, and are well laminated when of uniform composition. They weather rusty grey from the finely disseminated pyrite which they always carry. Microscopically the rock is composed of quartz in rounded lenticular and angular grains, with a development of strain shadows, fractures and occasional granulated borders. The sericite is present in clear and turbid aggregates of shreds and fibres. The pyrite is considerable and occurs in cubes in the sericite. The origin of the schists is not yet quite certain. In part it is derived from the carbonaceous slates, the transitional type being a light grey slate containing a little sericite and quartz, with an almost complete absence of carbon. In other parts the schist may represent some of the intercalated intrusives. The iron and copper sulphides were deposited simultaneously with the development of the schist, during the eruptive after-action produced by the intrusion of the granite. The faulting and brecciation prior to the deposition of the ore prepared in part the necessary channels for the solutions carrying the sulphates of iron and copper and the silica. The carbon in the slates no doubt had an important effect in reducing and precipitating the sulphates. A concentration took place at a later period in parts of the zone, and lenses of massive chalcopyrite, with quartz, were formed in parallel arrangement along the strike of the schist. These lenses range from an inch to several feet in width, and are the source of nearly all the clean ore. So far they have been found in the workings on the Jane, Fairview and Empress claims.

About seventy claims have been staked along this zone and adjacent to it. The principal groups are controlled by the Britannia Copper Syndicate, Ltd., the Empress Mining Co., and the Goldsmith Copper Co.

FIG. 2


BRITANNIA MINERAL ZONE
HOWE SOUND B.C.
Scale of Feet
1000 500 0 1000 2000 3000
Mineralized belt
Britannia Creek
Trail
Dam
Britannia Beach
Howe Sound
Wharf
Slate
Granite
L 892
COPPERDIKE 1981
COPPER CANYON
L 2001
EUREKA 1888
HUNTERS FRIEND 1917
GOLDSMITH
COLUMBIA 1883
STAG 1935
ALEX 1913
HELEN 1991
TRES 1934
ANNIE
1912
COPPER
CHEAPSIDE 1933
DAISY 1899
LOIS 1881
NEWCASTLE 1936
FANCY 1998
ST. LOUIS 2249
WANDERING JEW 2084
ADA 1961
LEOPOLD 1983
GYMPIE 1964
MINERAL CHIEF 1894
BRITANNIA
WILLIAM 1895
NANCY FR 1897
PASHA 1994
2012 SUTTON FR
SUMMIT 1995
MARGATE
1965
ROSE
1922
KALISPELL 1937
IMPERIAL 1990
LOTTIE H 1882
BLACK PRINCE 1972
EUROPA 1974
COPPER SYNDICATE
HEATHER FR. 1896
CLIFTON 1893
JANE 1892
Jane Bluff
PEARL FR.
BLUFF FR.
CROYDON 1925
SUMATRA 1924
THISTLE 1879
BRITANNIA L. 1996
EDITH
FAIRVIEW
VIOLET 1921
BENDIGO 1920
MAYBELLE FR.
FRITCHEY FR
BELL
CRACKERJACK
BONNER 1821
2015
LIDA H
EMPRESS
LAST CHANCE
VICTORIA
EMPEROR
KING
QUEEN
COMET
COLDIKE
COLDHILL
CHARMER
INDEPENDENT

1

2

3

1. GRANITE-SCHIST BRECCIA ALONG INTRUSIVE CONTACT, WORLCOMBE I.
2. FALLS, HEAD OF SALMON ARM.
3. STRATIFIED CLAYS, SHELTER I, THORNMANBY GROUP.

THE BRITANNIA COPPER SYNDICATE, LTD.*—The mines of this company are situated 3·8 miles from Britannia beach, and 3,500 feet above sea level. The company own seven claims comprising 297·04 acres on which there are 8,500 feet of lode.

Along the divide between Britannia and South valleys, 4,165 feet (bar.) above sea level, on the Fairview claim the ore body has been prospected over a width of 600 feet, by stripping, test pits and short tunnels, and numerous small lenses of chalcopyrite in quartz and schist have been exposed. The local strike varies from N. 25° W. to N. 60° W. with a southwest dip of 60°.

At present ore is mined only on the Jane claim at the Jane and Mammoth bluffs, which are separated by a fault valley. The Mammoth bluff (Pl. I) is 260 feet high and 600 feet long, with a visible width of 150 feet. It extends eastward into the Fairview claim. The exposures on the Jane and Fairview represent enormous bodies of low grade ore, and their position and topography favour economic methods of mining. The development is being carried on by means of tunnels, drifts, crosscuts, and glory holes. As the work progresses a great proportion of the ore will be mined from glory holes. No sinking on the ore body has been done below the 3,300 foot contour line.

The ore consists of finely disseminated pyrite, chalcopyrite in small masses and lenses with a little galena. Small amounts of bornite and covellite occur near the surface as secondary enrichment. The ore is essentially low grade, and about 60 per cent has to be concentrated before being shipped to the smelter. No recent assays are available, and the only information referring to values are those of the preliminary sampling of the ore bodies on the Jane claim, which appeared in the Annual Report of the Minister of Mines in 1904. In a series of samples from the Mammoth bluff, the average gave 3·84 per cent copper, 0·095 oz. gold, and 0·55 oz. silver per ton. Jane No. 1 gave from 4 to 13 per cent copper, and $1.50 to $2.00 in gold and silver from the more massive ore; and Jane No. 2 gave 5 per cent copper, and $1.75 in gold and silver per ton. An assay of the massive ore from Jane No. 2 made by Mr. M. F. Connor of the Survey gave 8·4 per cent copper.

The total number of tons mined and shipped up to January 1, 1907, was 168,396. Of this 42,552 tons was shipping ore and 65,844 con-

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*Annual Report of the Minister of Mines, British Columbia, 1899, pp. 812-814; 1900, pp. 930-934; 1904, pp. 261-265.
British Columbia Mining Record, vol. xii, no. xi, pp. 413-426.
W. M. Brewer, Eng. and Min. Jour., 1901, p. 189.

centrating. From the latter 12,612 tons of concentrates were milled. Both ore and concentrates are shipped to the company's smelter at Crofton on Vancouver island.

The company's plant is very extensive and well equipped for the economical handling of the ore. At the mine the ore is first crushed in the rock house at the head of the tramway by a Sturtevant rock crusher, and then passes on a conveyor where both clean ore and waste are picked off. The Riblet patent automatic aerial tramway is 16,800 feet long, built in two sections with an intermediate station, and connects the mines with the concentrator and shipping dock at the beach. The buckets carry 1,000 pounds of ore. The present tramway will be remodelled shortly and its capacity greatly increased.

The crushing plant at the beach consists of three Blake rock crushers, and two Gates rolls. The product from them is then sized in two sets of trommels with eight mm. screens, the oversize passing through rigid rolls. The whole product is separated on Hancock jigs, the clean ore going directly to the bins, while the tailings are ground in two Huntingdon and two Chilian mills, and conveyed to the concentrating mill in wooden launders.

The concentrating plant consists of two Cammett tables, eleven Wilfleys, twelve Overstroms, six Johnston, thirty-eight Frue vanners, two Sperry slimers, two sets of Richards classifiers, six settling tanks, and a Huntingdon mill for re-grinding the middlings. The concentrates are discharged into bins on the lower floor of the building, where the cars are loaded and the mineral transferred to the bins on the dock.

The electric plant which supplies both light and power to the mines and to the plant at the beach derives its power from Britannia creek. The creek is dammed 2·6 miles from the beach, which gives a fall of 1,950 feet with an ordinary pressure of 750 pounds. The water is conveyed in wire wound wooden pipes and steel pipes.

THE EMPRESS MINING CO.—This company has eight claims in South valley, adjoining the Britannia Copper Syndicate's property on the east. The ore body on the Empress claim is a continuation of that on the Fairview and is from 400 to 600 feet wide. Tunnels have been driven on the strike at 3,700, 3,500 and 3,320 feet (bar.) respectively, and about 2,000 feet of work was done during 1906. The ore is similar to that of the Britannia. A good trail has been built from the mouth of Furry creek to the mine, a distance of five miles, and other preparations are being made to ensure the mine reaching the shipping stage at an early date.

THE GOLDSMITH COPPER CO.—The company has a group of seventeen claims, situated between the Britannia Copper Syndicate's property and the beach. Little work has been done beyond some preliminary stripping and trenching.

In South valley, three miles inland, on the trail to the Empress, and 1,850 feet (bar.) above sea level, a claim has been staked by Messrs Kirk and McKinnon. The ore body is a contact deposit, with a granite gneiss foot-wall and a slate hanging. It strikes N. 50° W. and dips southwest at 75°. The ore body is two and a half feet wide and consists of a mixture of pyrrhotite, pyrite, chalcopyrite and zinc blende in a quartz-calcite-slate gangue. Only assessment work has been done so far, which has not been sufficient to open up a large body of ore.

BRITANNIA WEST COPPER CO.—The claims owned by this company are situated on the west side of Howe sound almost due north of Britannia beach. The second claim is about a quarter of a mile inland, and from 1,100 to 2,000 feet above sea level. It is more or less mineralized throughout. The country rock is a granite porphyry, which has suffered locally from intense shearing. Along these shear zones the rock is considerably altered, with a development of sericite and quartz carrying copper and iron pyrites, pyrrhotite, molybdenite and a little bornite. Superficially the ground has been tested by open cuts and short tunnels. It is stated that the ores carry appreciable values in gold and silver. The pyrrhotite was analysed by Mr. M. F. Connor and was found to contain 0.70 per cent nickel. The ore, which is low grade and very siliceous, will be favourable to water concentration.

A concentrating plant is being installed at the shore, and a gravity tramway is being built to connect it with the mine. Power will be developed from Cedar creek to the south. The topography of the deposits will admit of economic mining, but active development will not commence until the plant for treating the ore has been completed.

BOWEN ISLAND.

BONANZA MINE.—This mine is situated on the southwest slope of Mount Gardiner and 1,100 feet above sea level. The ore occurs in a zone of fracture in the cherts and chlorite schists, which crosses the strike. The width varies from nine inches to three feet and a half, but in the wider parts the ore is mixed with a considerable proportion of rock. A tunnel has been driven in on the ore body for 300 feet, but no further development has been done. The ore is a mixture of pyrite, zinc blende and galena and is stated to carry $6.40 in gold, 30 oz. of silver, and from 25 to 40 per cent lead. Messrs. Hubbard and Elliott of Chicago and Menach of Seattle are the joint owners.

JERVIS INLET.

On the southwest side of Queens reach, nearly opposite the entrance of Princess Louise inlet, a small deposit of pyrrhotite and chalcopyrite occurs along a diorite slate contact. A prospect tunnel four feet wide was driven in for thirty feet. An assay of the ore gave negative results for gold and silver.

South of Deserted bay, on the granite slate contact, small masses of arsenopyrite are found impregnating the granite. No large bodies have been discovered, as prospecting is very difficult along a contact which is so well concealed by talus and vegetation. An assay gave no values in gold or silver.

Five miles below Vancouver bay, on the east side of the inlet, some bodies of pyrrhotite occur in the schists of the Texada group. Fourteen claims have been staked, but nothing has been done to prove the value of these occurrences.

SEECHELT INLET.

GRANITE MOUNTAIN COPPER COMPANY.—This property is situated about three miles inland from the east side of the head of Salmon arm, and is at an elevation of 4,500 feet above the sea. It was first located in 1878, and was reported on about that time by Mr. R. B. Harper for the Provincial Government. The original locations have recently been increased to eighteen, which cover all the known outcrops on and around Mount Donaldson.

The country rock is granite, and the ore occurs in fissure veins. They are nine in number, one of which has been traced along the strike for 300 feet. The veins are parallel, and strike east and west with a dip of 65° to the north. On the surface they vary in width from three to twenty-five inches. The extreme veins are 1,600 feet from each other. Five hundred feet below the main outcrops a tunnel was driven on the main vein for thirty feet. This vein is three and three-quarter feet wide on the roof and four and a sixth feet wide on the floor. The ore is massive bornite with a little chalcocite and cuprite in quartz gangue. An assay of the massive ore made by Mr. J. O'Sullivan gave 0·4 oz. of gold, 35 oz. of silver, and 53% (wet) of copper.

The property is about sixty-four miles from Vancouver by way of Seechelt. The country is very rugged, but if the veins on development prove extensive ore bodies, an aerial tram line could be built from the mine to Salmon arm whence the transportation to the smelter offers no difficulties.

TEXADA ISLAND.

Texada island lies in the Strait of Georgia (Fig. 3), its southeast end being eighty miles north of Victoria and forty-seven from Vancouver. The town of Van Anda, where the chief working mines are situated, is about seventy-five miles from Vancouver, and is a port of call of the Union Steamship Company. The island has a length of thirty miles and a maximum width of six and a half miles. The shores are very rugged and Sturt, Blubber and Gillies bays afford the only good anchorage, the two latter being exposed to certain winds.

The western half of the island is more or less mineralized throughout, and has been nearly all staked at one time or another. It was in the early nineties that attention was first called to the occurrences of free gold in quartz, and later deposits of rich copper sulphides were found in the limestone formation. These latter were not considered of any great importance at the time, but subsequent development has proved the contrary. Prior to that, in 1872, Mr. James Richardson* and in 1885 Dr. Dawson,† called attention to and described the deposits of magnetite occurring on the southwest side of the island. Mr. W. M. Brewer has frequently described the progress of the mining industry of the island, in several papers published in different mining journals during the past ten years.‡

The ore deposits occur in the Texada group and along the contact of that group with the Marble Bay limestone formation.

DEPOSITS IN THE TEXADA GROUP.—In this group the ores are found along shear and fracture zones in the basic eruptive rocks. Much movement is shown by the slickensided walls, and later cross fractures have been developed in the ore bodies. The ores are galena, zinc blende, chalcopyrite and pyrite, carrying as a rule low values in gold and silver. The veins are pockety in character and massive ore abruptly alternates with barren zones. The veins are from two to four feet wide, in one case twelve feet, and from twenty to over 300 feet long.

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*Report of Progress, Geol. Sur. of Can. 1873-74, p. 99.
†Annual Report, Vol. II., Part B. Geol. Sur. of Can., pp. 36-38.
‡Eng. and Min. Jour. 1900, p. 651, and 1901, pp. 665-667.
Jour. of Can. Min. Inst., vol. viii, 1905, p. 172.

These deposits are not being worked at present, and consequently there was no opportunity to examine the underground workings as the mines

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almost east and west line, and from one tenth to half a mile inland. Denudation has exposed these lenticular bodies, and the more resistant magnetite stands in relief with respect to the country rocks. Over this area some fifteen distinct bodies are exposed. They occur along the contact of the limestone with granite and the greenstone, in the limestone with probably a greenstone floor, along greenstone granite contacts, and in the greenstone. In the two latter cases the limestone has all been removed by erosion. The granite passes into grano-diorite and quartz augite diorite. The greenstone is mainly augite porphyrite, now largely altered to chlorite and epidote schists. The limestone is crystalline in grey and white colours, is much faulted and generally has high dips to the south.

The more important deposits are known as the Texada, Paxton and Lake mines*. The Texada mine is the most western, and is about 200 yards from the shore, the collar of the shaft being 280 feet above sea level. The shaft is 150 feet deep, the bottom being connected with the surface by a tunnel driven in on a lower slope. The tunnel is over 300 feet long, and near the shaft seventy-four feet of magnetite were passed through, but no cross-cuts were made to determine the width of the ore. Magnetite also occurs on the surface at the shaft and at intervals on the slope to the north where it was formerly mined in quarries. The first quarry is 114 feet and the third 214 feet above the shaft. In the latter the width and length of the exposed ore body is twenty-six feet with a face over sixty-five feet high. Sufficient development work has not been done to determine if the bodies exposed in the quarries are connected with one another and with the one in the tunnel. If they were so connected, it would give an ore body about 500 feet long with a maximum surface width of thirty feet. The enclosing walls are quartz diorite on one side and limestone with greenstone on the other, except on the lower levels where diorite alone is exposed. Along the contact the diorite has been altered to a mixture of quartz, epidote, and garnet through which are small reticulating veins of magnetite.

The ore is a coarse crystalline magnetite which locally is impure from impregnations of copper and iron pyrites ; some of the ore having carried as high as 3 per cent copper, it was smelted at the Van Anda smelter some years ago. Quartz, actinolite, calcite, epidote and garnets are present in small amounts in parts of the ore bodies.

The Paxton mine is about 1,100 yards east of the above, half a mile inland and 400 feet above sea level. The ore body is 320 feet long, with a maximum width and height of 240 and 92 feet respectively. The ore lies on a floor of altered porphyrite which is also the north wall, the south wall being granite. The work on the first level consists of two open cuts and tunnels driven north, each thirty-five feet in the granite, and eight and fifty feet respectively in the ore. The magnetite at the contact is impure from rock and inclusions of sulphides, but farther in, some clean ore was mined. The impure ore disintegrates rapidly on exposure to the air and becomes covered with a white coating of iron sulphate.

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* Iron Ores of the Coast by W. F. Robertson. Annual Report of the Minister of Mines, British Columbia, 1902, pp. 225-229.

The Lake mine is one mile east of the Texada, and 400 feet above sea level. The ore rests on a floor of altered porphyrite with limestone as the north wall. The ore body is nearly 200 feet long, fifty feet wide, and the highest part is seventy feet above the first floor. A considerable portion of the ore body has been uncovered, and a short tunnel has been driven at the base. The ore is coarse and fine-grained crystalline magnetite with some hematite. The impurities are small amounts of copper and iron pyrites, epidote, actinolite, garnet, calcite and quartz.

Little has been done in exploiting the other deposits beyond delimiting their boundaries superficially. The development work on these magnetite deposits has not been extensive enough to show any great reserves of clean ore and at present it is not possible to make any statement regarding the amount of ore that would have any bearing on their actual importance. Much of the ore now exposed would require to be roasted to free it from sulphur. Regarding the variable amounts of copper which is disseminated through parts of the ore bodies it will probably be found that judicious selection will prevent the copper content in the roasted ore becoming high enough to materially vitiate the product for cast iron or steel. It is well known that copper in very small quantity strengthens and toughens steel and the metal may occur without injury in larger quantities in cast iron*

Several analyses of the magnetite have been made both of average lots and selected ore.

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* P. H. Thurston. Treatise on Iron and Steel, Part II. Chap. VIII. pp. 279-302.

——	I.	II.	III.	IV.	V.†
Iron	69·85	67·91	65·71	68·40	69·00
Silica	2·75	2·96	....	....	3·97
Manganese	tr.	....	....	....	
Sulphur	0·06	....	....	....	0·036
Phosphorous	tr.	....	·013	·003	·030
Lime	tr.	1·05	....	....	

These deposits were first located in 1875, and the lots were Crown granted. No record of the output was kept prior to 1884. The total amount shipped to date probably does not exceed 20,000 tons, and the greater part of this was smelted at Irondale in the State of Washington.

The deposits present good facilities for economic mining, principally by a system of quarries and tunnels. Gravity trams would transport the ore to the loading pier. The coast is somewhat exposed but there is deep water close to Gillies bay which in very stormy weather would make a safe harbour.

In 1902 some 6,000 tons were mined which cost, delivered at the Irondale smelter, $3.10 per ton, including a duty of 40 cents on the ton.* With properly equipped mining and transportation plant the cost could be very materially reduced.

Closely associated with the magnetites is a series of copper deposits *consisting* of chalcopyrite and a little carbonate. They occur as small irregular bodies along the contact of the limestone with the chlorite schist and magnetite. They are shallow deposits, and on the limestone-schist contact vary in attitude from almost vertical to horizontal with a limestone hanging wall or roof, and a schist foot wall or floor. The largest deposit had a length of 180 feet, with an average width of five feet, expanding in one place to twenty-four feet, and a maximum depth of twelve feet. Figure 4 is a cross section of this deposit showing its association with the country rock.

Over a dozen different bodies have so far been discovered, and some of them have been worked out. It is stated that over $10,000 worth

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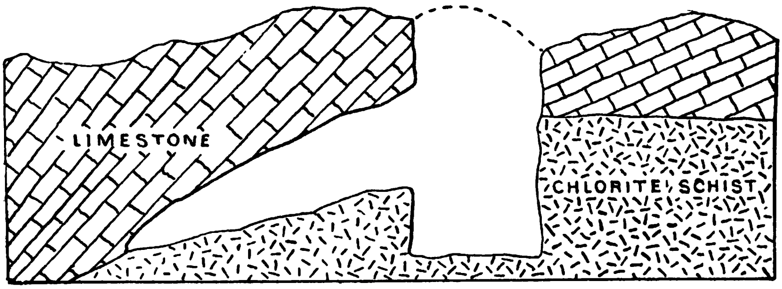
† I. Jour. of the Iron and Steel Inst. 1886, p. 561.
II. Fulmer. Geol. Sur. of Washington.
III. Whitfield. Tenth Census, U. S. (Mineral Industries) Vol. XV, p. 580. Lot of 600 tons.
IV. Dr. Harrington, Geol. Sur. of Canada.
V. E. I. Chapman, American Geologist, Vol. XX, p. 27, 1897.

*British Columbia Mining Record, vol. ix, No. 7, p. 221.



CROSS—SECTION
Showing form of Ore body (Copper)
On Puget Sound Iron Co's Property
Scale 11 feet = 1 inch.
FIGURE 4.

of ore has been mined, the average of some of the shipments giving ·08 to ·10 oz. of gold, 2 oz. of silver, and 8 to 10°/₀ copper per ton.

It is probable that along the schist-limestone contact other deposits may occur elsewhere with no surface indications, but it is doubtful if the amount of dead work necessary in prospecting would be compensated by the value of the ore bodies found.

ORIGIN OF THE MAGNETITES* AND CHALCOPYRITE.—The magnetites are secondary, and have evidently been produced by the decompositon of the basic eruptive rocks of the Texada group. These rocks when examined microscopically are found to be made up largely of secondary minerals, among which magnetite is a most productive member. In the formation of these bodies the ore solutions have followed the line of contact between the eruptives and the limestone, replacing the latter by magnetite. It seems to have been a direct precipitation of ore, with a liberation of lime carbonate, as the contact between the magnetite and limestone is always sharp, and iron carbonate is never, and ferruginous limestone rarely, seen. There are also residual concentrations of magnetite in the massive schist, and in extreme cases the latter is present as small cores in the ore. All the bodies were formed at considerable depth, and subsequent erosion has removed the overlying and surrounding limestone, sometimes completely, as in the case of the Paxton mine. The period of formation was prior to the intrusion of the Coast Range batholith, a small extension of which is found in contact with the ore at the Texada and Paxton mines. This intrusion altered the limestone, and produced new mineralizing agents, which during the cooling stages of the rock formed the copper deposits. The copper bearing solutions in many places penetrated the magnetite along fractures and incipient shear planes. At and near the contact, epidote, actinolite and garnets were formed, and a marginal zone of the granodiorite was replaced in part by these minerals along with quartz and copper and iron pyrites.

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*J. P. Kimball, American Geologist, vol. xx. 1897, pp. 16-23.

Other deposits of magnetite occur elsewhere on the island and are of the same origin as the above. They are, however, of minor importance.

The Volunteer claim, owned by the Tacoma Steel Co., is a quarter of a mile south of Marble bay. The magnetite occurs at the contact of a uralitic gabbro and the limestone. The ore body is sixty-five feet long with a maximum width of nine and three-quarter feet. The magnetite is coarse and fine grained and contains small amounts of actinolite, epidote and pyrite. An assay and partial analysis by Mr. F. C. Robinson gave ·0335 oz. of gold, 1·44 oz. of silver, and 62·4 per cent of iron. A small amount of this ore has been shipped for fluxing purposes.

The Security claim is half a mile south of Van Anda bay. The shaft is fifty feet deep, and the ore is a rather ill defined body along the contact of a porphyrite and pyroxene-garnet gangue rock. The ore is a mixture of magnetite and chalcopyrite, and an average sample gave on assay gold ·04 oz., copper (wet) 1·16 per cent., and iron 49·77 per cent.

North of the shaft a portion of the lead has been stripped and shows magnetite, chalcopyrite and pyrite from three to four feet wide, with a porphyrite foot and limestone hanging wall. This ore has been used in small quantities as a flux.

The Red Cloud claim, owned by the Raven Copper Gold Co., is situated a quarter of a mile inland from Spratt bay, and near a contact of the Texada group with an extension of the Coast Range batholith. An open cut extends east from the shaft for ninety-six feet, and a second cut fifty feet long is 160 feet east of the shaft. The shaft was sunk on the ore and is 130 feet deep The ore is a coarse platy magnetite with some pyrite in a calcite gangue, associated with granular magnetite which is finely interbanded with chalcopyrite and pyrrhotite, with garnets irregularly distributed through it. At the west end of the second open cut crystalline magnetite is exposed with a width of seven feet. Just immediately west on the same strike coarsely crystallized pyrite occurs to the exclusion of the magnetite.

This deposit is very irregular and the magnetite impure. The ore could only be used as a flux.

The Black Prince claim is one and a quarter miles inland from Pocahontas bay. The country rock is a fine-grained diorite. The lead is about 200 feet long and from fifteen inches to four feet wide. The strike is N. 35° W., and the dip 58° to the southwest. The ore is banded magnetite and pyrite, and the remnants of the limestone show its replacement from the rock. A lot of 2,100 pounds shipped to Van Anda smelter gave $13.50 gold.*

DEPOSITS IN THE MARBLE BAY LIMESTONE.—The ore deposits which occur wholly in the limestone have their chief development in the vicinity of the town of Van Anda. The three principal mines are the Copper Queen, Cornell and Marble Bay, of which the latter has been the most extensively developed.

THE MARBLE BAY MINE.—The Marble Bay mine is owned by the Tacoma Steel Co., who hold about 1,500 acres of Crown granted land in the western part of the island.

In 1897, an insignificant outcrop of copper and iron pyrites with some bornite was found about a quarter of a mile east of Sturt bay, on a lot owned by Messrs. Christie and Palmer, of Toronto. A shaft was sunk on the ore and drifts run but it was not until the 260 foot level was reached that the ore body assumed a definite character.

In 1902 the property was purchased by the present owners for $150,000, and it was extremely gratifying to the company to have been able to pay the whole of the purchase money out of the profits in three years.

The mine is now 771 feet deep, and 726 feet below high tide. The ore body from the 260 level to the present workings has varied in length from 70 to 105 feet, and in width from five to forty-five feet. On the first floor of the 771 level it is eighty-seven feet long with a maximum width of thirty-two feet. The strike on this floor is N. 45° W. and the walls are vertical.

From the surface to the 260 level the ore body was divided into subordinate shoots but below that level it has been one continuous shoot (Fig. 6). It pitches at a high angle to the north as far as the 460; from there it is practically vertical.

The ore shoot occurs in a zone of brecciation in a crystalline and semi-crystalline limestone, the zone being approximately parallel to

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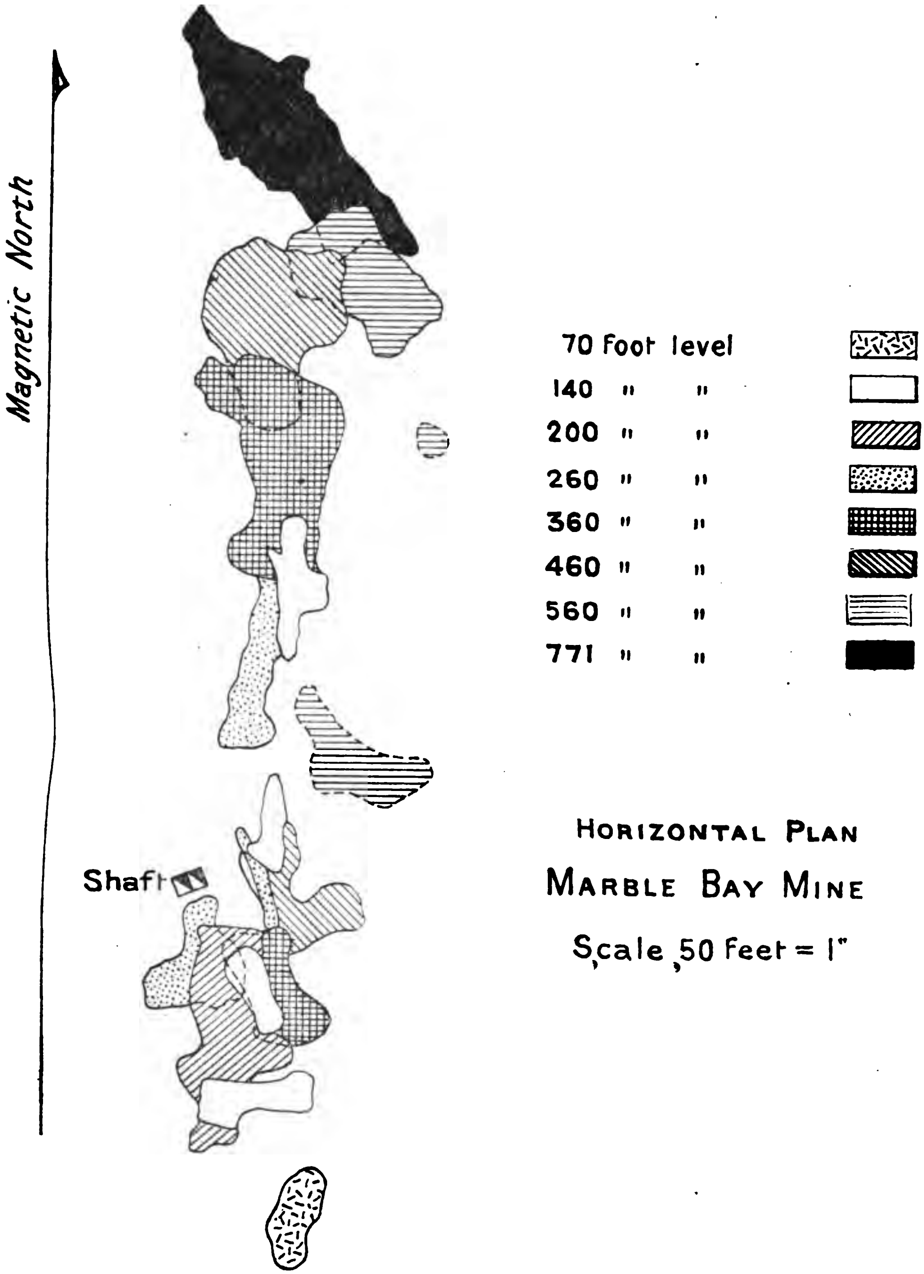
*Ann. Rep. of the Minister of Mines, British Columbia 1899, p. 804.

FIG. 5

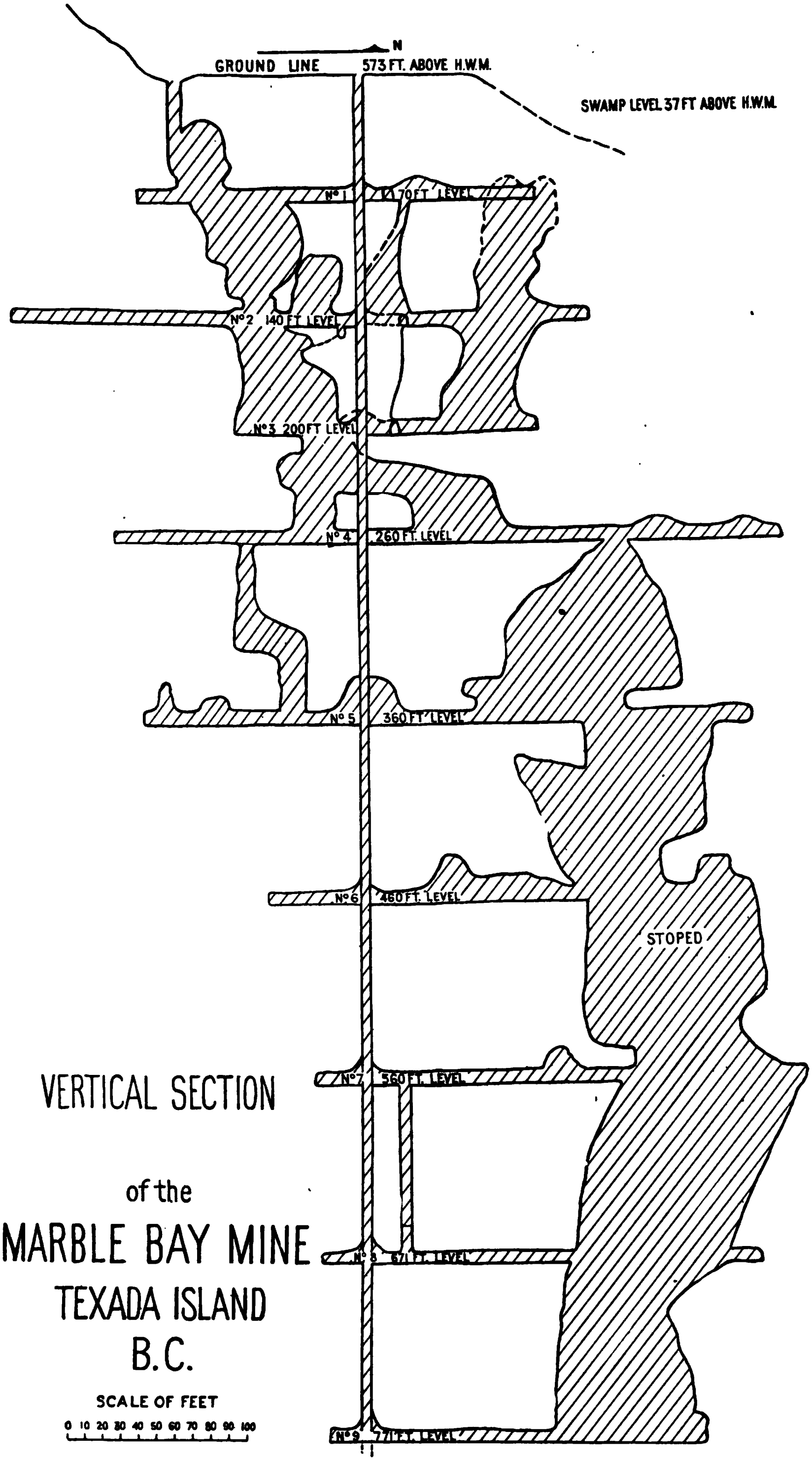


HORIZONTAL PLAN

MARBLE BAY MINE

Scale, 50 Feet = 1"

FIGURE 6.


N
GROUND LINE
573 FT. ABOVE H.W.M.
SWAMP LEVEL 37 FT ABOVE H.W.M.
Nº 1 70 FT LEVEL
Nº 2 140 FT LEVEL
Nº 3 200 FT LEVEL
Nº 4 260 FT. LEVEL
Nº 5 360 FT LEVEL
Nº 6 460 FT. LEVEL
STOPED
Nº 7 560 FT. LEVEL
Nº 8 671 FT. LEVEL
Nº 9 771 FT. LEVEL
VERTICAL SECTION
of the
MARBLE BAY MINE
TEXADA ISLAND
B.C.
SCALE OF FEET
0 10 20 30 40 50 60 70 80 90 100

the strike of the rock. The borders are broadly irregular, and small stringers of ore are occasionally given off which run into the wall rock for a few inches. In the upper levels the walls were much brecciated and weak, but in the lower they are firm and very little work is necessary in the way of lagging.

The ore is bornite with subordinate chalcopyrite and a little pyrite, pyrrhotite and molybdenite. These occur in a gangue of pale green pyroxene and pale reddish garnet, the "green" and "bull felsite" of the miners—and calcite. The ore is finely disseminated through the pyroxene, or occurs in large rather pure masses with calcite between the pyroxene and the limestone walls. Very little ore is found in the garnet, which is in fact generally barren A considerable proportion of the pyroxene is partially decomposed and disintegrates rapidly on exposure to the air. There are also large areas of pyroxene which are practically barren. Wedge shaped masses of limestone are occasionally found in the ore body, and represents areas not replaced by the gangue minerals and ore.

Subsequent to its formation, the ore shoot was cut by a dike of basic porphyrite, which, between the 7th and 8th levels, was from four to six feet wide. It dipped to the south at a high angle and diminishing in size on the 771 level it is only seven inches wide, and crosses the drift some distance south of the ore body. This intrusion caused considerable movement in parts of the ore body adjacent to it, producing small fractures and slickensides. The pyroxene and garnet were finely fractured, and in places granulated, with a redeposition of bornite along these planes.

The ore throughout is essentially high grade, and carries good values in gold and silver. That which is finely disseminated through the pyroxene carries much higher values in gold and silver than the purer and more massive bornite and chalcopyrite. It has also been noted that the percentage of copper has steadily increased with depth.

As it is necessary to mine considerable barren gangue which is intimately mixed with the productive, the ore is hand sorted before shipping, and graded into coarse and fines. The waste, on account of its fluxing properties, is shipped in large part, and sold to the smelter. At present the total output is sent to the Tacoma smelter for treatment.

In order to ascertain the average value of the ore, the smelter returns for the year beginning in June 1905 were examined and the following results tabulated :—

Grade.	Gold oz. per ton.	Silver oz. per ton	Copper p. c. (dry.)	Net value per ton.
Coarse	0·498	4·138	6·765	$28.77
Fines	0·1673	1·560	1·602	6.88
Waste	tr·—·08	0·15-0·9	0·22–0·8	0.50
Coarse —	1·006	5·73	11·25	

The last entry refers to a shipment of 116 tons of coarse grade made in July 1906.

About 13,000 tons are mined and shipped annually. From 1901 to 1906 inclusive, over 65,000 tons have been shipped. Through the courtesy of Mr. T. C. Robinson of the Sheffield Smelting Works it is possible to publish a few interesting assays which he made of the ore and gangue. The samples were taken from a stope on the 8th level.

—	Gold, oz. per long ton.	Silver, oz. per long ton.
I	0·40	18·60
II	1·05	7·85
III	0·008	0·04
IV	0·25	0·07

I. Bornite and chalcopyrite (massive ore.)

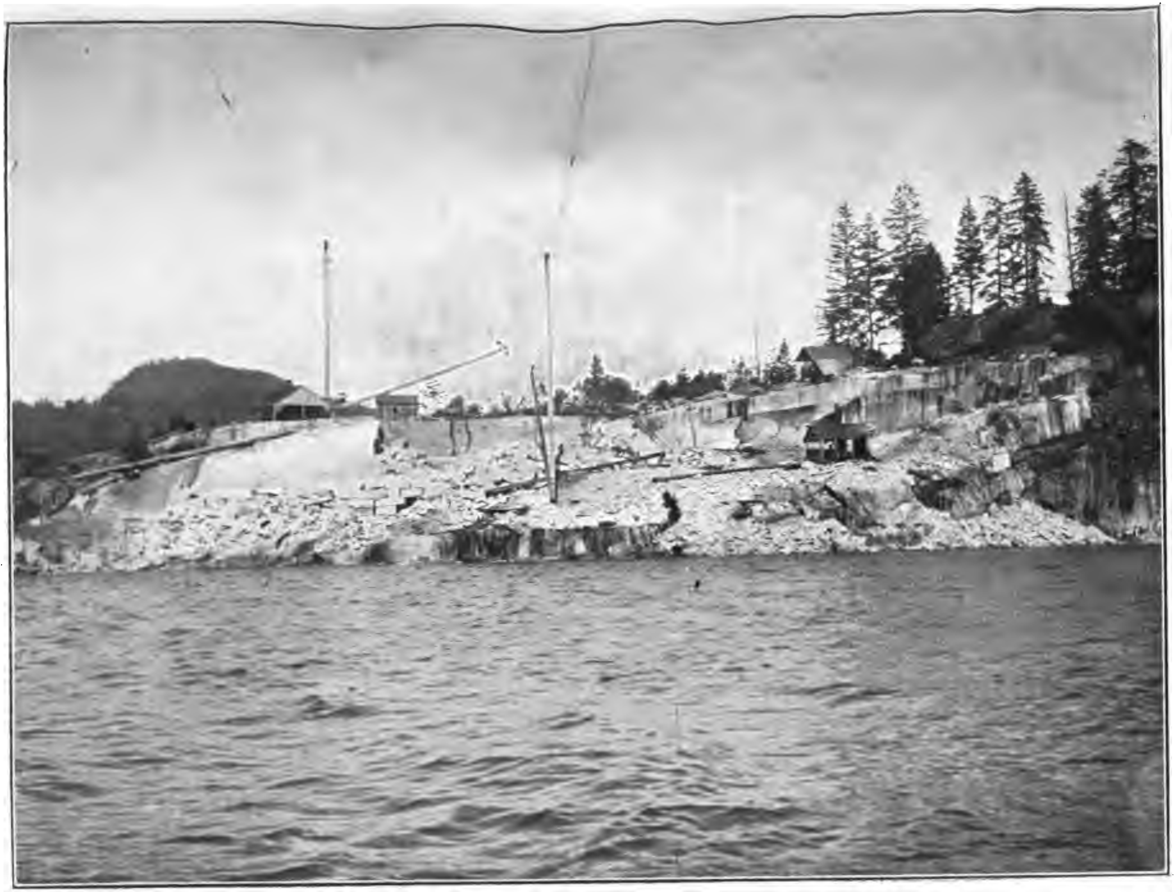
II. Pyroxene and garnet gangue with finely disseminated ore.

III. Calcite after removing mineralized portions.

IV. Calcite and garnet after removing mineralized portions. Numbers III and IV are interesting in showing the occurrence of gold and silver in what was apparently barren gangue. Free gold in distinguishable leaves and grains has been found occasionally but it is not common.

The mine is well equipped with a modern plant. The power plant consists of a two return tube externally fired boilers of 125 H.P. The steam is transmitted at 100 pounds pressure through a four inch pipe down the shaft to the 560 level, with a tee connexion at the 360 level to supply steam to the pumps there, which have to deal with the surface water. On this level there are two pumps, a Northey Cameron plunger type, and a Blake Differential sinking pump with a total capacity of 15,000 Imperial gallons per hour. Water cannot be retained at a higher level owing to a mud-slip which extends from the surface to

PLATE IV



ELLIS GRANITE QUARRY, NELSON ISLAND.

MnU

the 360. The retaining dam holds 25,000 gallons, which amount would collect in a fortnight in the dry season. In the winter, however, during the thaw of a heavy snowfall, or after continued heavy rains, it would fill in two or three hours. On the 560 level, a Cameron station pump raises, through a six inch column, any water escaping from the 360 as well as that pumped up from the bottom of the shaft. It has a capacity of 16,000 Imperial gallons per hour. It is required to operate the pumps 20 per cent of the time for six months, 50 per cent for five months, and full time for one month.

The mine water has a very corrosive action on the ordinary wrought iron pipes. The water from the lower levels is much more corrosive than that collected on the 360 level, as in the latter case the purely surface water flows down quickly and passes through channels which contain but little sulphides in their walls.

The power to work the drills is furnished by a duplex two stage air compressor of the Ingersoll Sergeant type with a capacity of ten drills. It is provided with a governor to limit the speed and pressure to 100 pounds.

The shaft is a double compartment with a four by five manway. Hoisting is done by a Lidgerwood geared hoist at a speed of between 360 and 450 feet per minute. The mine and camp are supplied with water at sixty-five pounds pressure from Priest lake, and a fifty light Westinghouse dynamo is used to illuminate the works at the surface and the company's hotel. The mine is connected by a tram line 2,125 feet long to the wharf, where the ore bunkers are situated.

The Copper Queen, Cornell and Little Billy are owned by the Van Anda Copper and Gold Mining Co. At present the two former are being worked under lease, the Copper Queen by the Copper Queen Operating Co., and the Cornell by Mr. J. A. Johnson, representing a Seattle syndicate. Both mines are connected by a tram line to the ore bunkers and wharf on Van Anda bay.

THE COPPER QUEEN.—The Copper Queen is situated half a mile from Van Anda bay. The shaft is 500 feet deep, and from the lowest level a winze was sunk for 240 feet, making in all 740 feet. The upper 680 feet has been nearly all stoped out. The ore shoot in the stoped areas varied from 40 to 100 feet in length, and from one to twenty feet in width. At the 680 foot level in the winze the ore shoot is eight to nine feet wide. Both walls are limestone with a strike of N. 47° W., and dip at 70° to the southwest. The lower sixty feet in the winze is in unstoped ore.

The ore is bornite and chalcopyrite with occasional rich masses of tetrahedrite in a pyroxene-garnet-calcite gangue. No recent assays are available, but the following will no doubt approximate closely the ore values in the lower workings. In 1897 a shipment of 300 tons gave ·34 oz. of gold, 6 oz. of silver, and 6·2 per cent copper per ton. In 1898 sorted ore yielded $7.00 in gold, 7 oz. of silver, and from 10 to 15 per cent copper.* On the 680 level in the winze a large mass of tremolite occurs along the hanging wall, which gave on assay ·05 per cent copper and $8.00 in gold. In 1900 the Van Anda smelter treated 7,054.75 tons of ore from the Queen, Cornell and Little Billy, which produced 827,844 pounds of copper, 10,563 oz. of silver, and 1,857.25 oz. of gold.

There is no good reason to doubt but that the ore shoot will continue with depth, and it is possible that careful and systematic prospecting might result in discovering parallel shoots on some of the upper levels. The limestone formation is much cut by dikes in this ground, and a favourite channel for deposition would be along the contact of the dikes and limestone. The main disadvantage that the mine labours under at present is that the shaft ends at the 500 foot level. In the present workings, the hoisting must be done through the winze and shaft, which is inconvenient and adds considerably to the expense.

THE CORNELL MINE.—The Cornell mine is three-quarters of a mile south of the Copper Queen, and is situated near the contact of the Texada group and the Marble Bay formation.

Work was first commenced on an ore shoot which outcropped to the east of the shaft. The shaft was sunk on ore to the 160 foot level, and then in a porphyrite dike and limestone to the 560. No work of any importance has been done below the 260 level. On the 160 level two ore shoots were found separated by a wedge of limestone. They were known as the Treat and Coney shoots and have been nearly all worked out. On the 260 level the ore shoot which may be connected with the above has a known length of 110 feet, a height of fifty feet and maximum width of fourteen feet.

The ores are bornite and chalcopyrite, with small amounts of magnetite and molybdenite, in a gangue composed of pyroxene, garnet and serpentine, the latter being in part the result of the decomposition of basic dikes intruded prior to the formation of the ore bodies.

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*Ann. Rep. of the Minister of Mines, British Columbia, 1897, p. 562; 1898, p. 1135; 1900, p. 925.

No recent assays of cargo lots are available, but it is probable the values are somewhat similar to those of the adjacent mines. It is stated that $270,000 worth of ore was produced between the surface and the 160 level. The ore from the glory hole was very rich, and carried as high as 1·25 oz. of gold to the ton.

The Little Billy is situated on the coast half a mile east of Van Anda bay. A small irregular body of chalcopyrite was found with the usual gangue minerals at the contact of limestone and granite. One thirty ton shipment gave $4 to $5 in gold, eighteen oz. of silver, and 12 per cent copper. Further prospecting failed to locate any other body though local conditions would seem to favour the occurrence of other shoots.

The Loyal mine, leased by Mr. D. O. Jacobs, representing a Seattle syndicate, is at the north end of the island and east of Blubber bay. Some years ago masses of bornite and chalcopyrite were discovered along a garnet-pyroxene and limestone contact. In some minor development seventy tons were shipped which yielded 17 per cent copper and twenty oz. of silver to the ton.*

Work was resumed by the present lessee about two years ago. The shaft in October, 1906, was 270 feet deep, with levels at 100 and 200 feet. About 1,200 feet of work has been done. The mineralized zone was three to six inches wide on the 100 level, and had broadened considerably on the 200, but as yet no large ore shoot had been encountered. The ore consists of pyrite, zinc blende, galena, chalcopyrite and bornite with calcite in brecciated limestone.

The Paris claim lies south of Blubber bay. Three shallow shafts have been sunk on a mineralized zone which lies along a limestone porphyrite contact. The ore is an irregular mixture of galena, copper and iron pyrites, zinc blende and magnetite, in a composite gangue of country rock, pyroxene and garnet.

The Canada group south of the Loyal, together with the rest of the coast belt extending to Sturt bay, has been only partially explored. It is a favourable field, and close prospecting may result in the discovery of new ore bodies. At the northwest end of the Canada group a shaft was sunk to a depth of fifty feet and rich copper ore was encountered thirty feet from the surface having a width of seven feet.

Origin of the Ore Shoots in the Limestone.—These deposits in point of view of origin are closely connected with the intrusion of the Coast

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*Ann. Rep. of the Minister of Mines, British Columbia, 1903, p 236.

Range batholith, extensions of which are found at several places on the north shore of the island and elsewhere. The deposits are clearly of pneumatolytic origin and can be referred to the Kristania type.*

It is well known that molten magmas give off enormous quantities of gases and vapours, which in this case would have a profound effect on the limestone through which they would pass along zones of brecciation, bedding planes and contact planes between basic dikes and limestones. Here the limestone has been replaced by silicates rich in lime, and by sulphide ores, with a consequent liberation of carbonic acid gas, the silica and sulphides coming from below in solution or gaseous form.

The deposition of the ore and gangue went on simultaneously with the cooling of the granite magma, and the ore bodies were formed before the intrusion of the aplite dikes, two of which were found cutting the ore bodies in the Copper Queen and Cornell.

Several sections of the gangue were made and subjected to a microscopical examination. The pyroxene,—variety omphacite—is colourless; and occurs in mosaics of clear individuals with turbid borders. The garnet is pale brown and shows zonary structure and optical anomalies. It is traversed by numerous cracks filled with chlorite and turbid calcite. Towards the calcite in the gangue the garnet shows a tendency to develop crystal outline. Bornite and chalcopyrite in small grains, solitary or connected in groups by narrow stringers, occur between the pyroxene individuals, or are included in them along cracks and cleavage planes.

In the Copper Queen and Cornell mines, where one wall is occasionally a basic dike, the decomposition of the dike has gone simultaneously with the deposition of the ore, and the latter is present in small bands and grains in felty serpentine, associated at times with narrow veins of asbestus. The ore-bearing serpentine occurs only in small masses, and is intimately connected with pyroxene and garnet.

Calcite with well formed crystals of garnet and vesuvianite and larger grains of the ores was the last to crystallize out and filled all the interstitial spaces.

The vesuvianite occurs in crystals with the two prisms, pyramid and end face (110, 100, 111, 001) developed. The garnet is andradite in rhombohedrons (110) and combinations of them and the tetratragonal trisoctahedron (211).

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*Genises of Ore Deposits.—Prof. J. H. L. Vogt, p. 648 et seq.; Waldemar Lindgren, p. 725 et seq.
Trans. Amer. Ins. of Min. Eng., vol. xxxiii.—H. W. Weed, Ore Deposits near Igneous Contacts, p. 715 et seq.

An approximate analysis of the pyroxene gangue by Mr. M. F. Connor, gave Silica 55·25, oxides of Iron and Alumina 6·50, oxide of Lime 25·00, oxide of Magnesia 14·00. The crystalline limestone in the vicinity of Marble Bay mine has the following composition; Insoluble 6·00, oxides of Iron and Alumina 0·30, Lime carbonate 86·00, Magnesia carbonate 7·60.

There are a few occurrences of ore in brecciated limestone without garnet and pyroxene gangue. The sulphides have been deposited in cracks with a small amount of calcite gangue. The Commodore is the only mine working on a deposit of this character. It is situated two and a half miles from Van Anda, at an elevation of 500 feet above sea level. The shaft was sunk on the contact of a diabase dike with the limestone which strikes N. 70° E, and dips south at 58°. At a vertical depth of 124 feet drifts were run both ways along the strike to tap mineralized zones which lie east and west of the shaft. In an open cut east of the shaft mineralized streaks were exposed in the limestone which contained zinc blende, pyrite, chalcopyrite and galena. A sample gave on assay 8·80 per cent lead, 29·20 per cent zinc, ·03 oz. of gold, and 15 oz. of silver to the ton.

The development up to November 1906 was of an exploratory nature, and no ore had been shipped.

STRUCTURAL STONE.

There are a number of quarries along the coast at present in operation which furnish both building stone and scrap for concrete work and road metal. The demand is readily supplied by the present workings.

Burrard inlet.—On the North arm there are two quarries near the head and opposite Croker island.

The rock in both cases is a light grey or white biotite granite, varying in grain from medium to coarse.

The Vancouver Quarry Company, formerly Keefer's quarry, on the west side of the arm, was first opened sixteen years ago, and has been worked more or less continuously ever since. The work extended inland from the shore, and there is now a working face about 100 feet high. The best building stone was taken from the front of the quarry, and as work progressed inwards the rock became so seamy that it was unfit for building purposes and is now used for road metal and concrete work. About seventy cubic yards a day are quarried. The company also owns a quarry on the west side of Croker island, where there is a good ledge suitable for building stone. The rock is taken to Vancouver in scows, and is broken to size by the Company's crushers on Westminster avenue.

The Coast Quarries Ltd. is situated on the east side of the arm. The granite cliff is about 120 feet high, but no work has been done above the forty foot level. A Farrel crusher breaks the rock into two and one inch and fines. A two drill Rand Compressor has been installed, the power being derived from a waterfall adjacent to the quarry.

On Fairview heights, Vancouver, there is a quarry owned by Messrs Nicholson and Morrison. The rock is an augite andesite and is used for road metal. It breaks readily under slight pressure and is of value only on roads where the traffic is light. It is used extensively by the British Columbia Electric Company, for ballasting their tracks.

JERVIS INLET.—At the entrance to the inlet on the southwest end of Nelson island an old quarry has recently been re-opened by the Ellis Granite Company of Seattle. The working face in the granite is at present about thirty feet high and 260 feet long. The rock is free from flaws and works well. The total production is shipped to Seattle. The granite taken from this quarry was used in the piers and abutments of the Provincial bridge over the Fraser at New Westminster.

Farther north on Granite island, and sixty miles from Vancouver, a granite quarry is operated by Messrs. Kelly and Murray. The main face is nearly 100 feet above sea level and about 175 feet long. The new post office at Vancouver is being built from rock taken from this quarry. At both the above quarries the rock is a light grey to white granite of medium and uniform grain. It is massive, free from objectionable flaws, works well and may be quarried in large blocks*.

The granites here were the best seen on this part of the coast.

At Deserted bay work was resumed at the old slate quarry in September last. The quarry is at sea level and to the east the slate hills rise to heights of 3,000 feet or more. The slate is a black carbonaceous finely laminated rock free from objectionable impurities. Traces of bedding show horizontal or with low dips, the plane of the cleavage being at right angles. In places small veins of quartz and calcite occur and small dikes of granite cut the slate. Slate, formerly quarried, was graded as first class, eighteen by ten inches, and third class fourteen by nine inches.

The former splits evenly and the latter not, giving a rough surface. The objection in the past work was that too much waste had to be handled, but it is stated that half a mile inland better and more uniform beds have been found that will permit of more economic working.

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* Ann. Rep. of the Minister of Mines, British Columbia, 1905, p. 251.

TEXADA ISLAND.—A fine grained pure white marble occurs at Blubber bay, Sturt bay and west of Paxton lake. Very little work has been done to prove the rock, but at Sturt bay, where a small amount was quarried, the rock in the upper layers was much jointed and large blocks could not be quarried. It is possible that other localities may furnish better indications for successful exploitation.

The limestones are generally very pure and when burned furnish a lime of excellent quality. The Tacoma Steel Co. have two kilns on Limekiln bay on the northwest end of the island. The rock is a dark grey unaltered limestone occurring inthick beds up to three and a half feet, and dipping seaward at from 15 to 25 degrees. The following analysis was made by Mr. M. F. Connor, of the Survey.

Carbonate of lime, 97·25.
Carbonate of magnesia, 2·25.
Oxide of iron and alumina, ·34.
Insoluble, ·30.

About 120 barrels of lime per day is the output which is shipped to Vancouver and to Suva, Java.

On Marble bay the same company has one kiln which is not worked regularly. The output here amounts to about 100 barrels per day.

CLAYS.

Very pure clays are found on the north arm of Burrard inlet, at the head of Howe sound on the east side and on Anvil island where they are used in the manufacture of brick.

On West Thornmanby island a very fine pure clay occurs interbedded with coarser clays and sands. This clay on drying produces very fine powder with an entire absence of grit. It makes good natural polishing powder for nickel, copper and other common utensils.

WATER POWER.

There are many streams in this region with high grade channels which will be used as as a source of power as future conditions demand. The fluctuation in volume during the year is considerable, and at present no data are available which would give an idea of their permanent or average value. This would entail a separate study of each stream. The streams fed by glaciers have a much greater value than those relying on the winter snows and general rain fall. Reference has also been made to Britannia creek which is one of the most important flowing into Howe sound. At the head of Salmon arm there is a fall of over sixty feet in the river draining the Clowhom lakes. The falls in Powell river have a maximum height of 120 feet. It has been estimated that 12,000 and 30,000 H. P. could be respectively developed from these two sources.

The British Columbia Electric Power Company's power house is situated on the north arm of Burrard inlet. Power is developed from the 400 foot fall from Lake Buntzen to tide-water. A tunnel two and a half miles long connects the above lake with Lake Choquitlam, the level of the latter being thirty-five feet higher, and this assures a sufficient supply of water for the extensive plant.

TIMBER.

Lumber is a very active industry in parts of the lowlands between Burrard inlet and the Fraser river and generally along the main coast and inlets. In the early stages of the industry timber was only cut along the shore in the broader valleys and on the general slopes. The growing demand has caused more extensive exploitation in the less accessible areas, and the cutting is extending farther inland each year.

Transportation to Tide-Water.—The logs are carried to tide-water by small railways and log chutes, where they are collected in booms and towed to the mills at Vancouver and elsewhere along the coast. In some of the valleys long flumes have been built along the creeks for the transportation of cedar shingle bolts.

The principal commercial woods are the Douglas fir (*Pseudotsuga douglasii*) and the western cedar (*Thuja gigantea*). The following species also occur in greater or less abundance in this region: Spruce (*Picea sitchensis*), hemlock (*Tsuga mertensiana*), yew (*Taxus brevifolia*), white pine (*Pinus monticola*), scrub pine (*Pinus contorta*), yellow cypress (*Thuya excelsa*), and alder (*Alnus rubra*).

Many of the older limits will shortly be worked over and considerable timber formerly thought valueless will be taken out.

The regrettable forest fires still break out every dry season and at times cause incalculable damage when they secure a foot-hold in good timber areas.

UNIV. OF MICH.

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(SINCE 1885)

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THE MINES DEPARTMENT OF CANADA

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858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
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Transcontinental location between Lake Nipigon and Sturgeon lake, Ont., by W. H. Collins.
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(B.—*Published by the Mines Branch.*)

On the location and examination of magnetic ore deposits by magnetometric measurements. Eugene Haanel. 1904.
Report of the Commission appointed to investigate the different electro-thermic processes for the smelting of iron ores and the making of steel in operation in Europe. (Only a few copies of this report are available.) By Eugene Haanel. 1904.
Final report on the experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Eugene Haanel. 1907.